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Stability of Parts-Per-Million Organic
Cylinder Gases and Results of Source
Test Analysis Audits: Status Report 8

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STABILITY OF PARTS-PER-MILLION ORGANIC CYLINDER GASES
AND RESULTS OF SOURCE TEST ANALYSIS AUDITS:
Status Report #8

by

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16. ABSTRACT A repository of 45 gaseous compounds including hydrocarbons, halocarbon, and sulfur species has been established under contract with the U. S. Environmental Protection Agency (USEPA). The main objectives of this on-going project are (1) to provide gas mixtures to EPA, state/local agencies, or their contractors, as performance audits to assess the accuracy of source emission measurements in certain organic chemical manufacturing industries, (2) to corroborate the vendor's certified analysis of the gas mixtures by in-house analysis, (3) to determine the stability of the gas mixtures with time by in-house analysis, and (4) to explore the feasibility of new audit materials as requested by EPA. Thus far, 31 compounds have been used to conduct 179 different audits. The results of these audits and a description of the experimental procedures used for analyses and available stability data are presented in the status report. Generally the audit results are within 15 percent of the expected values. Compound stabilities have been determined through multiple analyses of the cylinders containing them. Stability data for up to 8 years is available for many compounds and over 5 years for most compounds. Compounds that are unstable and not suitable for use as an audit materials are identified.		
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FOREWORD

Source measurement and monitoring efforts are designed to anticipate potential environmental problems, to support regulatory actions by developing data bases needed in developing regulations and to provide means of monitoring compliance with regulations. The Environmental Monitoring Systems Laboratory, Research Triangle Park, North Carolina, has the responsibility for implementation of agency-wide Quality Assurance programs for air pollution measurement systems; and supplying technical support to other groups in the Agency including the Office of Air and Radiation, the Office of Toxic Substances, and the Office of Enforcement.

The need for reliable standards for auditing and documenting the accuracy of source emission measurement of gaseous hydrocarbons, halocarbons, and sulfur compounds is well established. The Quality Assurance Division of EPA's Environmental Monitoring Systems Laboratory has responded to this need through the development of an extensive repository of gaseous compounds in the parts-per-million (PPM) levels in compressed gas cylinders. The primary objectives of this ongoing project are (1) to provide accurate gas mixtures to EPA, state/local agencies, or their contractors for performance audits to assess the accuracy of source emission measurements in certain organic chemical manufacturing industries, (2) to verify the vendor's certified analysis of the gas mixtures, (3) to determine the stability of gas mixtures with time, and (4) to develop new audit materials as requested by EPA. This report describes the current status of this project. Included in the report are (1) a description of the experimental procedures used for the analyses of gas mixtures, (2) a description of the audit procedure, and (3) currently available audit results and stability data.

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SECTION 1 INTRODUCTION

OBJECTIVES

The need for reliable standards for auditing source emission measurement of gaseous hydrocarbons, halocarbons, oxygenated, and sulfurous compounds is well established. The Research Triangle Institute (RTI), under contract to the U.S. Environmental Protection Agency (EPA), has responded to this need through the development of an extensive repository of 39 gaseous compounds. The primary objectives of this ongoing project are (1) to provide accurate gas mixtures to EPA, state/local agencies, or their contractors for performance audits to assess the relative accuracy of source emission measurements in certain organic chemical manufacturing industries, (2) to examine the vendor's certified analysis of the gas mixtures by in-house analysis, (3) to determine the stability of the gas mixtures with time by in-house analysis, and (4) to develop new audit materials, as requested by EPA.

This report describes the current status of this project. Included are (1) a description of the experimental procedures used for initial cylinder analyses and collection of stability data, (2) a description of the audit procedure, and (3) currently available audit results and stability data. Complete details of the study with statistical analyses for ten (10) halocarbons and eight (8) other organics are presented in two journal publications (1,2).

AUDIT MATERIALS CONTAINED IN THE REPOSITORY

Currently, 45 gaseous compounds have been investigated as audit materials. Six compounds have been found to be unstable in cylinders and not suitable as audit materials. The other 39 gaseous compounds in the repository are suitable for conducting performance audits during source testing. The compounds were selected based on the anticipated needs of the Emission Measurement Branch, Office of Air Quality Planning and Standards, U.S. EPA. Table 1 lists the 45 mixtures, the concentration ranges, the number of cylinders of each compound currently in the repository, and the cylinder construction material. In Table 1,

the audit materials fall into two concentration ranges. The low concentration range, between 5 and 50 parts per million (ppm), simulates possible emission standard levels. The high concentration range, between 50 and 700 ppm, simulates expected source emission levels. The balance gas for all gas mixtures is nitrogen.

TABLE 1. AUDIT MATERIALS CURRENTLY IN THE REPOSITORY

Compound	Low Concentration Range			High Concentration Range		
	No. of Cylinders	Concentration Range (ppm)	Cylinder Construction*	No. of Cylinders	Concentration Range (ppm)	Cylinder Construction*
Benzene	7	5 - 20	S	10	60 - 400	S
Ethylene	3	5 - 20	Al	4	300 - 700	Al
				6	3000 - 20,000	Al
Propylene	3	5 - 20	Al	3	300 - 700	Al
Methane/Ethane	-	—	—	4	1000 - 9000(M), 200 - 800(E)	Al
Propane	3	5 - 20	Al	3	300 - 700	Al
				4	1000 - 20,000	Al
Toluene	4	5 - 20	Al	4	100 - 700	LS
Hydrogen Sulfide	7	5 - 50	Al	7	100 - 700	Al
Meta-Xylene	2	5 - 20	S	2	300 - 700	LS
Methyl Acetate	2	5 - 20	S	2	300 - 700	S
Chloroform	4	5 - 20	S	1	300 - 700	S
Carbonyl Sulfide	1	5 - 20	Al	4	100 - 400	Al
Methyl Mercaptan	3	3 - 10	Al	-	—	-
Hexane	2	20 - 90	Al	1	1000 - 3000	LS
1,2-Dichloroethane	4	5 - 20	Al	4	100 - 600	Al
Cyclohexane	-	—	—	1	80 - 200	Al
Methyl Ethyl Ketone	1	30 - 80	S	-	—	-
Methanol	1	30 - 80	Al	-	—	-
1,2-Dichloropropane	2	3 - 20	Al	2	300 - 700	Al
Trichloroethylene	2	5 - 20	Al	2	100 - 600	Al
1,1-Dichloro- ethylene	2	5 - 20	Al	2	100 - 600	Al
**1,2-Dibromo- ethylene	-	—	—	-	—	—
Perchloro- ethylene	2	5 - 20	S	2	300 - 700	LS
Vinyl Chloride	8	5 - 30	S	-	—	—
1,3-Butadiene	3	5 - 60	Al	-	—	—
Acrylonitrile	3	5 - 20	Al	1	300 - 500	Al
**Aniline	-	—	—	-	—	—
Methyl Isobutyl Ketone	1	5 - 20	Al	-	—	—

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Cylinders are no longer available; the compounds were found to be unstable in the cylinders.

(Continued)

TABLE 1. AUDIT MATERIALS CURRENTLY IN THE REPOSITORY (Continued)

Compound	Low Concentration Range			High Concentration Range		
	No. of Cylinders	Concentration Range (ppm)	Cylinder Construction*	No. of Cylinders	Concentration Range (ppm)	Cylinder Construction*
**Para-dichlorobenzene	-	—	—	-	—	—
**Ethylamine	-	—	—	-	—	—
**Formaldehyde	-	—	—	-	—	—
Methylene Chloride	3	1 - 20	Al	-	—	—
Carbon Tetrachloride	4	5 - 20	Al	-	—	—
Freon 113	1	5 - 20	Al	-	—	—
Methyl Chloroform	1	5 - 20	Al	-	—	—
Ethylene Oxide	5	5 - 20	Al	-	—	—
Propylene Oxide	1	5 - 20	Al	1	75 - 200	Al
Allyl Chloride	1	5 - 20	S	1	75 - 200	S
Acrolein	1	5 - 20	Al	1	100 - 300	Al
Chlorobenzene	3	5 - 20	Al	-	—	—
Carbon Disulfide	-	—	-	1	75 - 200	Al
**Cyclohexanone	-	—	-	-	—	—
***EPA Method 25 Mixture	6	100 - 200	Al	2	750 - 2000	Al
Ethylene Dibromide	2	5 - 20	S	2	50 - 300	S
Tetrachloroethane	1	5 - 20	S	-	—	—

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Cylinders are no longer available; the compounds were found to be unstable in the cylinders.

***The gas mixture contains an aliphatic hydrocarbon, an aromatic hydrocarbon, and carbon dioxide in nitrogen. Concentrations shown are in ppmC.

SECTION 2

EXPERIMENTAL PROCEDURES

Analysis of the cylinder gases is required to corroborate the concentrations reported by the company which prepared the gas mixtures and also to measure concentration changes with time, that is, estimate stability of the compounds.

INSTRUMENTATION

Analyses are presently performed with (1) a Perkin-Elmer Sigma 4 Gas Chromatograph with a flame ionization detector (FID), and (2) a Tracor 560 Gas Chromatograph with a flame photometric detector. The flame photometric detector has principally been used for measurement of the sulfur-containing species. Gaseous samples are injected onto the appropriate column by means of Valco gas sampling valves constructed of Hastalloy C (high nickel content and low adsorptive properties). These valves are equipped with interchangeable sample loops to allow the injection of variable volumes of gas.

An oxidation/reduction GC-FID is used for verification of calibration mixture concentrations. This system consists of a Tracor 560 gas chromatograph with a flame ionization detector, a thermal oxidation reactor (38cm long X 10mm OD quartz tube heated to 800°C), and a methanation reactor (14 inch long X 1/4 inch OD stainless steel tube packed with -100 mesh nickel powder and heated to 400°C).

The gas chromatographic parameters used in the measurement of individual compounds and any problems with the analysis are listed in Attachment 1.

CALIBRATION

Calibration of the gas chromatographs is accomplished using appropriate calibration standards comprised of known concentrations of gases in air or nitrogen. The source or method of preparation of calibration standards varies depending on the gas involved.

National Bureau of Standards, Standard Reference Materials (NBS-SRMs) of methane and propane in nitrogen or air were used for the calibration of the GC for the measurement of methane, ethane, propane, ethylene, and propylene audit materials. An NBS-SRM of benzene in

nitrogen was used for calibration of the GC for the measurement of benzene audit cylinder concentrations.

A second method for preparation of calibration standards involves the use of gravimetrically calibrated permeation tubes. For example, the calibration gases for vinyl chloride and ethylene oxide have been generated in this manner. The permeation tube is placed in a temperature-controlled chamber and nitrogen is passed over the permeation tube at a known flow rate. The resultant gaseous mixture is further diluted, if necessary, using additional nitrogen in a glass dilution bulb. The final mixture is collected in a gas sampling syringe and analyzed by GC-FID. The permeation rates of the tubes are determined by periodic weight loss measurements.

A third method for developing a calibration standard is the pressure-dilution technique. A known volume of the compound, either gas or liquid, is injected into an evacuated glass bulb or stainless steel sphere of known volume. (The volume of the bulb or sphere is determined gravimetrically.) The bulb or sphere is then pressurized with a balance gas of choice. If a pure liquid is injected, total vaporization is assumed and the concentration is calculated by using the ideal gas law. Additional dilutions are also made, if necessary, by partially evacuating to a known pressure and pressurizing with a balance gas to a known pressure.

With each of these approaches, multipoint calibration curves are prepared each time a cylinder mixture is analyzed.

QUALITY CONTROL

Replicate injections of both audit cylinder gases and calibration standards are performed until no trends in the detector response are observed and the relative standard deviation of replicate injections is less than 1 percent.

Instead of depending totally upon the pressure-dilution technique for the determination of calibration mixture concentrations, an internal quality control check has been implemented to allow verification of the calibration mixture concentration. This involves analyzing the calibration mixture with the oxidation/reduction GC-FID described in Section 2 (Instrumentation). A 1 cc sample of the calibration mixture

is injected via a 6-port rotary valve. The sample is swept into the thermal reactor with a 5 percent oxygen in nitrogen carrier gas where the organic compound is converted to carbon dioxide, water, and possibly some halogenated products. The halogens are removed from the carrier with powdered o-tolidine packed into a 1/4 inch OD glass tube. The carbon dioxide and water pass into the methanation reactor where CO₂ is converted to methane which is subsequently detected by FID. By converting all organic species to methane, the problem of FID response variability to different compounds is avoided. The analyzer is calibrated with NBS-SRMs of propane in nitrogen. If the calculated concentration of the calibration mixture and the measured concentration agree within 2 percent, the calculated concentration is used as the standard for analysis of cylinder concentrations. If there is greater than 2 percent difference, the calibration mixture preparation is repeated. Data generated from verification of calibration mixtures in some recent analyses is shown in Table 2. A more comprehensive summary of quality control data will be given in a future report.

TABLE 2. QUALITY CONTROL RESULTS ON CALIBRATION MIXTURES
FOR SELECTED COMPOUNDS

Compound	Calculated Conc., ppm (by pressure-dilution)	Measured Conc., ppm (by oxid/red)	Percent Difference*
Methyl ethyl ketone	116	116	0
Methyl acetate	645	642	-0.5
Methanol	260	257	-1.2
1,1-Dichloroethylene	311	315	1.3
Trichloroethylene	560	570	1.8
Tetrachloroethylene	510	517	1.4
Cyclohexane	97.9	98.4	0.5
Hexane	71.9	72.4	0.7

$$\text{*Percent Difference} = \frac{\text{Measured Conc.} - \text{Calculated Conc.}}{\text{Calculated Concentration}} \times 100$$

SECTION 3 PERFORMANCE AUDITS

RTI supplies repository cylinders for audits upon request from the EPA, state or local agencies or contractors. A contractor must be performing source emission tests at the request of EPA or a state or local agency in order to qualify for the performance audit. When a request is received, the contents of the cylinders are analyzed, the tank pressures are measured and the cylinders are shipped by overland carrier. Tank regulators are also provided when requested. A letter is included with the cylinders which provides general instructions for performance of the audit. The audit material concentration and cylinder pressure are provided to the requesting agency audit coordinator.

To date, 176 individual audits have been initiated, and 166 are complete. The audit results currently available are presented in Table 3. Generally, the results of the audits show agreement of ± 15 percent with the audit material concentrations measured by RTI, although the difference for some compounds is sometimes quite substantial. This indicates the importance of the performance audit program and the need for reliable quality assurance calibration standards by the laboratories being audited.

TABLE 3. SUMMARY OF PERFORMANCE AUDIT RESULTS

Audit No.	Client***	Industry	Audit material	RTI audit conc. (ppm)	Client audit % bias (Avg.)*	Status of audit**
1	A	Ethylene oxide production	Ethylene in N ₂ Ethylene in N ₂	3,240 21,200	-22.5 -20.0	E
2	A	Ethylene oxide production	Methane/ethane in N ₂ Methane/ethane in N ₂	1,710Me/220Et 8,130Me/597Et	+9/-20 +9/-1.00	E
3	A	Ethylene oxide production	Methane/ethane in N ₂ Methane/ethane in N ₂	1,021Me/315Et 6,207Me/773Et	+21.5/-4.50 +23.5/-4.50	E
4	A	Acetone production	Benzene in N ₂ Benzene in N ₂	79.0 374.0	-19.0 -11.0	E
5	A	Maleic anhydride production	Benzene in N ₂ Benzene in N ₂	138 300	-9.40 +4.70	E
6	A	Ethylene oxide production	Ethylene in N ₂ Ethylene in N ₂	5,440 18,900	-27.0 -33.0	E
7	B	Maleic anhydride production	Benzene in N ₂ Benzene in N ₂	80.0 355	+2.30 +27.5	E
8	C	Maleic anhydride production	Benzene in N ₂ Benzene in N ₂	101 387	+12.9 +14.5	E
9	D	Ethyl benzene styrene manufacturer	Benzene in N ₂ Benzene in N ₂	71.0 229	-2.80 -3.90	E
10	E	Gasoline bulk terminal	Benzene in N ₂ Benzene in N ₂	62.0 80.0	+3.80 +3.40	E
11	F	Gasoline transfer terminal	Benzene in N ₂ Benzene in N ₂	142 294	-3.50 +3.20	E
12	F	Gasoline transfer terminal	Benzene in N ₂ Benzene in N ₂	268 343	-11.8 -1.00	E

TABLE 3. SUMMARY OF PERFORMANCE AUDIT RESULTS (Continued)

Audit No.	Client***	Industry	Audit material	RTI Audit conc. (ppm)	Client Audit % bias (Avg.)*	Status of audit**
13	F	Gasoline transfer terminal	Benzene in N ₂ Benzene in N ₂	129 318	+4.70 +8.70	E
14	F	Gasoline transfer terminal	Benzene in N ₂	10.7	+2.60	E
15	C	Nitrobenzene manufacturing	Benzene in N ₂ Benzene in N ₂	9.73 269	-4.60 -2.60	E
16	F	Gasoline bulk terminal	Benzene in N ₂ Benzene in N ₂	8.20 140	-2.30 -1.80	E
17a	F	Gasoline bulk terminal	Benzene in N ₂ Benzene in N ₂	9.50 127	+10.4 -2.80	E
17b	F	Gasoline bulk terminal	Benzene in N ₂ Benzene in N ₂	9.50 127	+12.5 -6.30	E
18	G	Coke oven	Hydrogen sulfide in N ₂ Hydrogen sulfide in N ₂	7.05 9.73	-24.8 -22.9	E
19	F	Gasoline bulk terminal	Benzene in N ₂ Benzene in N ₂	12.0 218	-0.80 +7.30	E
20	F	Gasoline bulk terminal	Benzene in N ₂ Benzene in N ₂	7.65 396	+16.3 +1.50	E
21	F	Linear alkyl-benzene manufacturing	Benzene in N ₂ Benzene in N ₂ Benzene in N ₂	98.0 294 331	+5.70 +6.80 +4.50	E
22	F	Gasoline bulk terminal	Benzene in N ₂ Benzene in N ₂	9.85 81.0	-4.10 -6.80	E
23	F	Gasoline bulk terminal	Benzene in N ₂ Benzene in N ₂	10.2 61.0	+4.60 -9.50	E

TABLE 3. SUMMARY OF PERFORMANCE AUDIT RESULTS (Continued)

Audit No.	Client***	Industry	Audit material	RTI audit conc. (ppm)	Client audit % bias (Avg.)*	Status of audit**
24	H	Industrial surface coating process	Toluene in N ₂ Propylene in N ₂ Propane in N ₂ Methane/ethane in N ₂	14.8 474 20.3 1,640Ne/195Set	-1.90 +0.20 -2.30 -13.5(as methane)	E
25	C	Acrylic acid and ester Production	Propane in N ₂ Propane in N ₂	10.1 710	+8.60 +5.60	E
26	C	Acrylic acid and ester Production	Propane in N ₂ Propane in N ₂	5.1 607	+17.6 -3.60	E
27	E	Maleic anhydride	Benzene in N ₂ Benzene in N ₂	10.2 218	NA NA	F
28A	A	Carbon adsorber	Toluene in N ₂ Toluene in N ₂	8.55 405	-6.40 -1.00	E
28B	A	Carbon adsorber	Toluene in N ₂ Toluene in N ₂	8.55 405	+4.10 NA	E
28C	A	Carbon adsorber	Toluene in N ₂ Toluene in N ₂	8.55 405	-8.80 NA	E
29	EPA, QAD	Instrument check-out	Ethylene in N ₂ Ethylene in N ₂ Ethylene in N ₂ Ethylene in N ₂ Ethylene in N ₂	4.75 19.6 312 3020 20400	+4.00 +3.10 -0.80 +5.30 -8.60	E

TABLE 3. SUMMARY OF PERFORMANCE AUDIT RESULTS (Continued)

Audit No.	Client***	Industry	Audit material	RTI Audit conc. (ppm)	Client Audit % bias (Avg.)*	Status of audit**
30	EPA, QAD	Instrument check-out	Benzene in N ₂	8.20	+0.30	E
			Benzene in N ₂	78.0	-0.90	
			Benzene in N ₂	133	-4.00	
			Benzene in N ₂	348	-0.90	
31	EPA, QAD	Instrument check-out	Toluene in N ₂	405	+3.20	E
			Toluene in N ₂	579	+1.00	
32	EPA, QAD	Instrument check-out	Methyl acetate in N ₂	6.80	-2.60	E
			Methyl acetate in N ₂	17.2	+1.70	
			Methyl acetate in N ₂	326	-1.50	
			Methyl acetate in N ₂	455	-1.30	
33	EPA, QAD	Instrument check-out	Propylene in N ₂	4.90	-22.4	E
			Propylene in N ₂	19.7	-7.80	
			Propylene in N ₂	300	+1.00	
			Propylene in N ₂	685	-1.80	
34	EPA, QAD	Instrument check-out	Propane in N ₂	14.6	-0.70	E
			Propane in N ₂	303	+7.60	
			Propane in N ₂	439	+6.20	
35a	I	Vegetable oil plant	Hexane in N ₂	82.2	+8.10	E
			Hexane in N ₂	1980	+3.00	
35b	I	Vegetable oil plant	Hexane in N ₂	82.2	-1.20	E
			Hexane in N ₂	1980	-1.30	
36	A	Carbon adsorber	Toluene in N ₂	8.20	-2.40	E

TABLE 3. SUMMARY OF PERFORMANCE AUDIT RESULTS (Continued)

Audit No.	Client***	Industry	Audit material	RTI audit conc. (ppm)	Client audit % bias (Avg.)*	Status of audit**
37	B	Coke oven	Benzene in N ₂ Benzene in N ₂	12.1 105	+0.80 +2.90	E
38	D	Ethylbenzene/ styrene	Benzene in N ₂ Benzene in N ₂ Benzene in N ₂	9.90 77.9 345	+5.70 +3.60 +1.50	E
39	B	Coke oven Byproduct	Benzene in N ₂ Benzene in N ₂	8.20 85.4	-2.60 -8.70	E
40	D	Coke oven Byproduct	Benzene in N ₂ Benzene in N ₂	10.9 147	+20.0 +6.80	
41	H	Paint spray	Benzene in N ₂ m-Xylene in N ₂	10.8 16.4	NA NA	F
42	H	Tire manufacturing	Cyclohexane in N ₂	93.4	-11.1	E
43	B	Coke oven	Benzene in N ₂ Benzene in N ₂	7.54 225	+0.10 +0.40	D
44	D	Ethylbenzene/ styrene	Benzene in N ₂ Benzene in N ₂ Propane in N ₂	8.20 74.5 10.6	-3.40 -0.20 -3.00	D
45	F	Industrial surface coating	Propane in Air Propane in Air	316 450	-3.20 -2.00	E
46	EPA, QAD	Tire manufacturing	Propane in Air Propane in Air	15.0 316	NA NA	F

TABLE 3. SUMMARY OF PERFORMANCE AUDIT RESULTS (Continued)

Audit No.	Client***	Industry	Audit material	RTI audit conc. (ppm)	Client audit % bias (Avg.)*	Status of audit**
47	EPA, QAD	Tire manufacturing	Propane in air Propane in air	20.8 453	-18.4 +13.4	E
48	D	Dimethyl terephthalate production	Meta-xylene in N ₂	487	-2.10	E
49	EPA, QAD	Instrument check-out	Toluene in N ₂ Methanol in N ₂	61.5 55.2	NA NA	F
50	EPA, QAD	Tire oven manufacturing	Propane in air Propane in air Propane in air	4.90 613 718	-48.8 +16.9 +16.8	E
51	EPA, QAD	Instrument check-out	Propane in air Propane in air	20.8 316	+20.0 -9.20	E
52	D	Styrene manufacturing	Benzene in N ₂ Benzene in N ₂ 1,3-Butadiene in N ₂	106 358 20.9	-4.90 -3.70 +23.8	E
53	I	Veg. oil manufacturing	Cyclohexane in N ₂	99.0	-3.50	E
54	M	Research	Chloroform in N ₂ Chloroform in N ₂	16.5 531	NA NA	F
55	J	Research	Ethylene in N ₂	300	+1.40	E

TABLE 3. SUMMARY OF PERFORMANCE AUDIT RESULTS (Continued)

Audit No.	Client***	Industry	Audit material	KIT audit conc. (ppm)	Client audit % bias (Avg.)*	Status of audit**
56	K	Reactivity of vent activated charcoal	Chloroform in N ₂	8.11	NA	F
57	EPA, QAD	Instrument check-out	Hydrogen sulfide in N ₂	16.2	NA	F
58	C	Coil coating	Propane in Air Propane in Air	5.20 472	NA -8.40	E
59	L	Maleic anhydride	Benzene in N ₂ Benzene in N ₂	9.45 341	NA NA	F
60	M	Research	Audit not initiated	—	—	—
61	EPA (State of Conn.)	Maleic anhydride	Benzene in N ₂	133	NA	F
62	O		Meta-xylene in N ₂ Hexane in N ₂	760 1990	NA NA	F
63	M	Paper and pulp	Methyl mercaptan in N ₂	4.44	NA	F
64	P	Research	Benzene in N ₂ Methyl ethyl ketone in N ₂	13.4 44.5	NA NA	F
65	E	Coke oven Byproduct Recovery	Benzene in N ₂ Benzene in N ₂	7.93 132	-2.90 +1.39	E

TABLE 3. SUMMARY OF PERFORMANCE AUDIT RESULTS (Continued)

Audit No.	Client***	Industry	Audit material	RTI audit conc. (ppm)	Client audit % bias (Avg.)*	Status of audit**
66	D	Rubber manufacturing	Benzene in N ₂ Benzene in N ₂ Benzene in N ₂ Benzene in N ₂ Hexane in N ₂ Hexane in N ₂ Propane in Air Propane in Air	12.0 10.2 100 335 79.8 3080 9.97 314	+14.2 0 +6.40 +6.00 +1.80 -7.50 -3.20 -10.8	E
67	E	Coke oven Byproduct Recovery	Benzene in N ₂ Benzene in N ₂	8.29 75.7	-2.20 -2.50	E
68	EPA, Region II	Vinyl chloride manufacturing	Vinyl chloride in N ₂ Vinyl chloride in N ₂	5.74 28.3	NA NA	F
69	EPA, QAD	Instrument Check	Propylene in N ₂ Propylene in N ₂	328 725	-7.00 -8.30	E
70	EPA, Region I	Vinyl chloride manufacturing	Vinyl chloride in N ₂	7.50	NA	F
71	E	Degreasing vent	Trichloroethylene in N ₂ Trichloroethylene in N ₂	14.9 566	-0.40 -8.70	E
72	EPA, QAD	Instrument check-out	Hexane in N ₂	3080	NA	F
73	EPA, QAD	Combustion efficiency test	Hydrogen sulfide in N ₂ Methyl mercaptan in N ₂	16.2 8.22	-7.50 -8.90	E

TABLE 3. SUMMARY OF PERFORMANCE AUDIT RESULTS (Continued)

Audit No.	Client***	Industry	Audit material	RTI audit conc. (ppm)	Client audit % bias (Avg.)*	Status of audit**
74	E	Vinyl chloride manufacturing	1,2-Dichloroethane in N ₂ 1,2-Dichloroethane in N ₂	9.30 462	+6.00 +3.70	E
75	N	Coil coating	Propane in air Propane in air	10.0 309	NA NA	F
76	F	Coil coating	Propane in air Propane in air	10.0 309	NA NA	F
77	D	Maleic anhydride	Benzene in N ₂ Benzene in N ₂	9.46 66.9	-6.60 -11.7	E
78	EPA, Region VII	Instrument checkout	Benzene in N ₂ Hexane in N ₂	120 30.2	NA NA	F
79	D	Maleic anhydride	Benzene in N ₂ Benzene in N ₂	9.46 128	-4.60 +12.5	E
80	F	Plywood/veneer drying	Propylene in N ₂ Propylene in N ₂ Toluene in N ₂	14.8 328 430	-4.70 +4.40 -0.80	E
81	P	Plywood/veneer drying	Propylene in N ₂ Propylene in N ₂ Toluene in N ₂	20.3 479 487	+18.2 -22.5 +32.5	E
82	J	Polypropylene manufacturing	Propylene in N ₂ Propane in N ₂ Propane in N ₂	9.63 19.7 296	-0.35 +0.84 +0.45	E
83	I	Coke oven	Hydrogen sulfide in N ₂ Hydrogen sulfide in N ₂ Carbonyl sulfide	437 647 101	+4.90 -16.5 +1.98	E

TABLE 3. SUMMARY OF PERFORMANCE AUDIT RESULTS (Continued)

Audit No.	Client***	Industry	Audit material	RTI audit		Client audit % bias (Avg.)*	Status of audit**
				conc. (ppm)			
84	J	Compliance testing	Benzene in N ₂	7.45		23.0	E
			Hexane in N ₂	72.6		0.6	
			Toluene in N ₂	15.0		-8.7	
			Methyl mercaptan in N ₂	5.40		NA	
85	I	Steel manufacturing	Hydrogen sulfide in N ₂	647		5.0	E
			Carbonyl sulfide in N ₂	9.08		1.0	
86	I	Oil shale	Hydrogen sulfide in N ₂	437		-3.0	E
			Carbonyl sulfide in N ₂	117		-4.6	
			Methyl mercaptan in N ₂	8.42		-13.3	
87	Q	Maleic Anhydride Production	Benzene in N ₂	55.7		+528.4	E
			Hexane in N ₂	324		+20.5	
88	R	Refining	Hydrogen sulfide in N ₂	17.5		21.1	E
			Hydrogen sulfide in N ₂	437		22.0	
89	Air Quality Bureau, New Mexico	Refining	Hydrogen sulfide in N ₂	647		NA	F
90	S	Oil shale	Carbonyl sulfide in N ₂	117		-29.1	E
			Methyl mercaptan in N ₂	8.42		-14.8	
			Hydrogen sulfide in N ₂	437		-3.65	
91	F	Compliance testing & demonstration	Trichlorethylene in N ₂	94.6		NA	E
			Propane in N ₂	10.0		NA	
			Propane in N ₂	309		-54.0	
			Propane in N ₂	73.8		8.7	

TABLE 3. SUMMARY OF PERFORMANCE AUDIT RESULTS (Continued)

Audit No.	Client***	Industry	Audit material	RTI audit conc. (ppm)	Client audit % bias (Avg.)*	Status of audit**
92	EPA, Region I	Research Method Development	Toluene in N ₂	34.7	NA	F
93	D	Method Validation	Hydrogen sulfide in N ₂	8.32	NA	F
94	USEPA, Region I	Research-Method Development	Vinyl chloride in N ₂ 1,1-dichloroethylene in N ₂ Trichloroethylene in N ₂ Perchloroethylene in N ₂	8.39 14.2 13.5 7.94	-20.2 +10.6 +55.6 +48.1	E
95	E	Acrylonitrile Production	Acrylonitrile in N ₂ Acrylonitrile in N ₂	413 10.8	NA 6.94	E
96	USEPA, Region I	Resource Recovery Garbage Burning Emissions	Propane in N ₂ Propane in N ₂	10.0 296	-35.0 -17.2	E
97	Tewksbury State Hospital, MA	Research-Method Development	Vinyl chloride in N ₂ 1,1-dichloroethylene in N ₂ Trichloroethylene in N ₂ Tetrachloroethylene in N ₂	8.39 14.2 13.5 7.94	+57 -9.9 -4.4 +48.6	E
98	T	Plywood Veneer	Method 25 gas in N ₂ Method 25 gas in N ₂	102 as C 1940 as C	NA NA	F
99	U	Hazardous Materials Incineration	Trichloroethylene in N ₂ Perchloroethylene in N ₂ Chloroform in N ₂	8.91 7.94 16.5	NA NA NA	F

TABLE 3. SUMMARY OF PERFORMANCE AUDIT RESULTS (Continued)

Audit No.	Client**	Industry	Audit material	RTI audit conc. (ppm)	Client audit % bias (Avg.)*	Status of audit**
100	USEPA, Region I	Research Method Development	Chlorobenzene in N ₂ Benzene in N ₂ Hexane in N ₂ Meta-xylene in N ₂	9.20 128 30.2 6.82 (cold bulb) 2.68 (warm bulb)	NA NA NA NA	F
101	U	Hazardous Materials Incineration	Trichloroethylene in N ₂ Perchloroethylene in N ₂	13.5 14.5	NA NA	F
102	Allegheny County	Source Testing	Toluene in N ₂ Methyl ethyl ketone in N ₂ Acrylonitrile in N ₂ Methyl isobutyl ketone in N ₂	8.51 38.7 11.6 9.49	NA NA NA NA	F
103	I	Hazardous Waste Incineration	Vinylidene chloride in N ₂	14.2	12.3	E
104	I	Hazardous Waste Incineration	Vinylidene chloride in N ₂	9.00	10.0	E
105	USEPA, Region VI	Plastics	Vinyl chloride in N ₂	8.41	NA	F
106	USEPA, Region VI	Vinyl Chloride Manufacturing	Vinyl chloride in N ₂	8.44	NA	F
107	V	Instrument Check	Methyl chloroform in N ₂ Perchloroethylene in N ₂	10.2 7.94	+7.8 +15.9	E
108	Q	Gasoline Terminal	Propane in air	1.18%	-4.2	E
109	P	Chemicals Manufacturing	Toluene in N ₂ Benzene in N ₂ 1,2-dichloroethane in N ₂	16.4 7.3 8.1	17.3 NA NA	E
110	MD Dept. of Health	Instrument Check	Benzene in N ₂ Perchloroethylene in N ₂	9.64 14.5	-6.6 +60.1	E

TABLE 3. SUMMARY OF PERFORMANCE AUDIT RESULTS (Continued)

Audit No.	Client***	Industry	Audit material	RTI audit conc. (ppm)	Client audit % bias (Avg.)*	Status of audit**
111	V	Instrument Check	Chloroform in N ₂ Carbon tetrachloride in N ₂ Trichloroethylene in N ₂ Freon 113 in N ₂	16.5 10.5 13.5 9.76	+3 +33.0 +4.0 0	E
112	J	Research, Method Development	Propane in N ₂ Toluene in N ₂	628 347	+0.6 +2.0	E
113	GA State EPA	Plastics	Vinyl chloride in N ₂	8.44	+10.2	E
114	Sacramento County, California	Instrument Check	Ethylene oxide in N ₂	10.1	NA	F
115	W	Instrument Check	Benzene in N ₂ Chlorobenzene in N ₂	389 9.20	-35.7 -43.1	E
116	V	Instrument Check	Methanol in N ₂	55.2	NA	F
117	X	Carbon Adsorption	Toluene in N ₂ Methyl ethyl ketone in N ₂ Methylene chloride in N ₂	16.1 38.7 9.67	NA NA NA	F
118	F	Surface Coating	Method 25 gas in N ₂	96.8 as C	+127.3	E
119	K	Source Testing	Freon 113 in N ₂	9.76	NA	F
120	Z	Source Testing	Toluene in N ₂ Toluene in N ₂	8.51 558	+38.8 -3.1	E
121	K	Source Testing	Perchloroethylene in N ₂	7.94	NA	F
122	IA State EPA	Source Testing	Benzene in N ₂ Vinyl chloride in N ₂ 1,2-dichloroethane in N ₂ Carbon tetrachloride in N ₂	9.64 8.44 13.8 10.5	-30.5 191.5 -37.0 -40.0	E
123	C	Paper Manufacturing	Vinyl chloride in N ₂	6.60	NA	F

TABLE 3. SUMMARY OF PERFORMANCE AUDIT RESULTS (Continued)

Audit No.	Client***	Industry	Audit material	RT audit conc. (ppm)	Client audit % bias (Avg.)*	Status of audit**
124	LA State EPA	Instrument Check	Toluene in N ₂ Methylene chloride in N ₂	8.51 9.67	-34.2 96.8	E
125	Y	Surface Coating	Method 25 gas in N ₂ Method 25 gas in N ₂	107 as C 775 as C	80.4 39.5	E
126	I	Oil Shale	Carbonyl sulfide in N ₂ Carbonyl sulfide in N ₂ Hydrogen sulfide Methyl mercaptan	10.7 116 627 8.42	NA NA NA NA	F
127	F	Surface Coating	Method 25 gas in N ₂	775 as C	-26.5, -18.7	E
128	Y	Surface Coating	Method 25 gas in N ₂ Method 25 gas in N ₂	205 as C 1040 as C	21.5 18.9	E
129	J	Research, Method Development	Methyl ethyl ketone in N ₂	38.7	NA	F
130	Region VII	Source Testing	Acrylonitrile in N ₂	11.6	-29.3	E
131A	South Coast Air Quality Management District	Hazardous Waste Landfill	Benzene in N ₂ Methane in N ₂	134 6460	-28 +0.6	E
131B	South Coast Air Quality Management District	Hazardous Waste Landfill	Methane in N ₂	6460	-2.5	E
132	Maryland Dept. of Health	Instrument Check	Benzene in N ₂ Trichloroethylene in N ₂ Hexane in N ₂ Methyl isobutyl ketone in N ₂ 1,2-Dichloroethane in N ₂	7.9 9.4 32.8 8.4 13.9	-11.1 -31.6 -18.5 +15.4 -2.1	E
133	State of California Air Resources Board	Quality Assurance Audit of Standards	Methylene chloride in N ₂ Chloroform in N ₂ Perchloroethylene in N ₂ Carbon tetrachloride in N ₂ Trichloroethylene in N ₂ Freon-113 in N ₂	9.2 4.6 10.5 9.6 14.0 11.0	+7.6 +2.2 +14.3 +1.0 +7.1 -9.1	E

TABLE 3. SUMMARY OF PERFORMANCE AUDIT RESULTS (Continued)

Audit No.	Client***	Industry	Audit material	RTI audit conc. (ppm)	Client audit % bias (Avg.)*	Status of audit**
134	AA	Source Testing	Benzene in N ₂	310	+5.2	E
135	FF	Source Testing	Method 25 gas in N ₂	103.8 as C	+28.1	E
136	J	Instrument Check	Benzene in N ₂ Benzene in N ₂	10.3 121	+12.2 +6.2	E
137	I	Source Testing	Method 25 gas in N ₂	195 as C	-18.3	E
138	F	Compliance Testing	Methanol in N ₂	48.8	+10.7	E
139	BB	Source Testing	Methyl ethyl ketone in N ₂ Method 25 gas in N ₂	40.4 1060 as C	-5.9 -4.0	E
140	EPA Region II	Metal Refining	Benzene in N ₂	376	-11.2	E
141	Commonwealth of Massachusetts	Instrument Check	Benzene in N ₂ Trichloroethylene in N ₂ Methyl ethyl ketone in N ₂	7.9 14.0 40.4	+5.1 -4.3 +31.2	E
142	EPA Region II	Source Testing	Benzene in N ₂	7.8	-5.1	E
143	State of Delaware	Plastic Manufacturing	Vinyl chloride in N ₂ Vinyl chloride in N ₂	7.75 20.3	-11.0 -10.3	E
144	EE	Plastic Manufacturing	Method 25 gas in N ₂ Propane in air	96.1 as C 10.9	-24.5 -4.6	E
145	DD	Paper Coating	Toluene in N ₂	546	-8.6	E
146	State of Delaware	Instrument Check	Benzene in N ₂	7.9	-20.6	E
147	OC	Gasoline Terminal	Propane in N ₂	2052	NA	F
148	F	Vinyl Coating	Propane in N ₂	308	-1.0	E
149	BB	Plastic Manufacturing	Methyl ethyl ketone in N ₂ Method 25 gas in N ₂	40.4 764 as C	-25 -9.3	E

TABLE 3. SUMMARY OF PERFORMANCE AUDIT RESULTS (Continued)

Audit No.	Client***	Industry	Audit material	RTI audit conc. (ppm)	Client audit % bias (Avg.)*	Status of audit**
150	EPA Region I	Wire Coating	Method 25 gas in N ₂	187 as C	+52.0	E
151	EPA Region II	Instrument Check	Benzene in N ₂ Method 25 gas in N ₂ Method 25 gas in N ₂ Methyl ethyl ketone in N ₂	9.90 1930 as C 95.8 as C 40.4	-5.4 -71.0 -73.1 +220	E
152	EPA Region II	Source Testing	Benzene in N ₂ Benzene in N ₂ 1,1-Dichloroethylene in N ₂ 1,1-Dichloroethylene in N ₂	96.0 10.2 8.78 479	-5.5 +3.0 NA NA	E
153	Commonwealth of Massachusetts	Paper Coating	Propane in N ₂ Propane in N ₂	10.9 607	NA +3.1	E
154	J	Instrument Check	1,2-Dichloroethane in N ₂ Trichloroethylene in N ₂ Perchloroethylene in N ₂	14.1 9.40 13.3	-11.3 -1.1 -2.3	E
155	EPA Region I	Source Testing	Toluene in N ₂	184	NA	F
156	EPA Region II	Source Testing	Method 25 gas in N ₂	1020 as C	-48.2	E
157	EPA Region I	Source Testing	Hexane in N ₂	88.2	NA	F
158	Allegheny County	Instrument Check	Benzene in N ₂ Toluene in N ₂ Trichloroethylene in N ₂ Perchloroethylene in N ₂ Propane in N ₂ Hydrogen Sulfide in N ₂	11.9 8.70 14.0 6.88 10.9 30.5	-2.5 NA NA -93.0 NA NA	E
159	Minnesota Pollution Control Agency	Instrument Check	Benzene in N ₂ Toluene in N ₂	10.3 18.9	-37 -30	E
160	J	Source Testing	Methylene Chloride in N ₂ Methylene Chloride in N ₂	10.4 6.01	-4.0 -3.7	E

TABLE 3. SUMMARY OF PERFORMANCE AUDIT RESULTS (Continued)

Audit No.	Client**	Industry	Audit material	RTI audit conc. (ppm)	Client audit % bias (Avg.)*	Status of audit**
161	Florida Dept. of Health, Welfare and Bioenvironmental Services	Printing Operation	Method 25 gas in N ₂ Method 25 gas in N ₂	1930 as C 187 as C	+16 +55	E
162	Texas Air Control Board	Instrument Check	Benzene in N ₂ Acrylonitrile in N ₂	97.3 424	+2.8 -33	E
163	Pennsylvania Dept. of Environmental Resources	Source Testing	Method 25 gas in N ₂ Method 25 gas in N ₂	1093 as C 99.2 as C	-11 +69	E
164	OG	Printing Operation	Method 25 gas in N ₂	196 as C		A
165	EPA Region I	Paper Coating	Toluene in N ₂ Toluene in N ₂	618 368	+36.9 +11.4	D
166	Texas Air Control Board	Source Testing	Method 25 gas in N ₂	99.6 as C	+5.7	E
167	State of Delaware	Source Testing	Vinyl Chloride in N ₂ Vinyl Chloride in N ₂	8.15 20.6	+0.6 +0.5	E
168	J	Instrument Check	Benzene in N ₂	7.89	-9.6	E
169	N	Source Testing	Method 25 gas in N ₂ Method 25 gas in N ₂	196 as C 1093 as C	+30.6 +13.4	D
170	State of Delaware	Source Testing	Method 25 gas in N ₂ Method 25 gas in N ₂	99.2 as C 806 as C		A
171	J	Methylene Chloride Manufacturing	Methylene Chloride in N ₂ Methylene Chloride in N ₂	1.13 10.4		A
172	N	Solvent Coating	Method 25 gas in N ₂ Method 25 gas in N ₂	196 as C 806 as C		A

TABLE 3. SUMMARY OF PERFORMANCE AUDIT RESULTS (Continued)

Audit No.	Client***	Industry	Audit material	RTI audit conc. (ppm)	Client audit % bias (Avg.)*	Status of audit**
173	HH	Steam Stripping	1,2-Dichloroethane in N ₂ Vinyl Chloride in N ₂ Methylene Chloride in N ₂	422 7.75 6.01		A
174	EPA/ASRL	Lab #1, Inst. #1	Benzene in N ₂ Toluene in N ₂ 1,3-Butadiene in N ₂ Meta-Xylene in N ₂	7.89 10.2 13.4 11.1	+0.6 -14.4 -9.2 -10.8	B
		Lab #1, Inst. #2	Benzene in N ₂ Toluene in N ₂ 1,3-Butadiene in N ₂ Meta-Xylene in N ₂	7.89 10.2 13.4 11.1	-3.2 -8.6 -10.8 -9.2	B
		Lab #2	Benzene in N ₂ Toluene in N ₂ 1,3-Butadiene in N ₂ Meta-Xylene in N ₂	7.89 10.2 13.4 11.1		A
175	II	Instrument Check	Method 25 gas in N ₂	806 as C		A
176	L	Synthetic Rubber Manufacturing	Chloroform in N ₂ Carbon Tetrachloride in N ₂	9.08 5.88		A

NA = Not Analyzed
 *Client % Bias = 100 X $\frac{\text{Client-Measured Concentration} - \text{RTI-Measured Concentration}}{\text{RTI-Measured Concentration}}$

**Status Codes:
 A = Cylinder shipped; audit results not yet received;

B = Audit results received;

C = Audit report submitted to EPA;

D = Audit results received, audit report submitted to EPA, cylinder not yet returned by client;

E = Audit complete;

F = Audit completed without analysis of audit materials by client.

***Whenever the auditee is known, an alphabetical letter is shown. Whenever the auditee is unknown, the name of the agency requesting the audit is shown.

1977 - Audits 1-8

1978 - Audits 9-28

1979 - Audits 29-49

1980 - Audits 50-75

1981 - Audits 76-82

1982 - Audits 83-86

1983 - Audits 87-106

1984 - Audits 107-130

1985 - Audits 131-159

1986 - Audits 160-176

SECTION 4

STABILITY STUDIES

An ideal calibration standard or audit material should be not only accurate, but stable over its total time of usage. The stabilities of the compounds in the repository were studied through periodic analyses of the cylinder contents. In this project, the gas mixtures in the repository are initially analyzed upon receipt from the specialty gas vendor to corroborate the vendor's analysis. If the RTI analysis result differs from the vendor's value by more than 10 percent, the cylinder is given to a third party (EPA or NBS) for analysis. The gas mixtures are again analyzed at 1 month, at 2 months, and at one year following the initial analysis to determine the stability of the gas mixtures. In some cases, analyses are not performed on the dates specified above; however, every attempt is made to acquire the data on this schedule. Some cylinders have also been analyzed yearly after completion of the new cylinder stability study, providing additional data for estimating stability.

As the number of analyses per cylinder increases, statistical stability analyses will be performed. The results will be presented in a future report. Statistical stability analyses for ten (10) halocarbons and eight (8) other organics have been published in the open literature (1,2).

Absolute accuracies of the cylinder analyses have not been determined due to the lack of NBS standards above one ppm for most of the organic gas mixtures. An examination of the data in Attachment 1 shows that values for individual cylinder analyses usually vary less than 10 percent between analyses for 4-8 analyses over 2-6 years. This variation indicates changes in cylinder contents (i.e., instability) and/or the imprecision of the measurement process. The possible sources of experimental error that could result in apparent differences in concentrations include (1) the variability of the analytical technique used for analysis, (2) stability of and/or accuracy of calibration standards, and (3) the accuracy of reproducing standards for which NBS-SRMs do not exist. Each of these sources of variability contributes to the net uncertainty of the resulting data presented in Attachment 1.

Estimates of day-to-day measurement uncertainty (repeatability) for all compounds have not been performed. However, the measurement uncertainties for ten halocarbons have been published (2). The measurement uncertainty varied from less than 1 to 10 percent depending on the compound, and the major portion of the uncertainty was attributed to the method of preparation of the calibration standard. The uncertainty for the gas chromatographic analysis was determined to be less than 2 percent by multiple injections of the gas during same day analysis.

For the most recent analyses shown in Attachment 1, the uncertainty in the concentration has been estimated based on consideration of the uncertainties of several parameters associated with the measurement and calibration procedures. The equation below was then used to estimate the total uncertainty based on the individual uncertainties.

$$\text{Total Uncertainty} = 2 \left(\sum_{i=1}^n e_i^2 \right)^{1/2}$$

Where:

- 2 = two standard deviations (95 percent confidence limit)
- e_i = individual component error, (percent coefficient of variation)
- n = total number of error components.

For analyses involving the use of NBS-SRMs as calibration standards, the total uncertainty is estimated to be 3.5 percent; for analyses using permeation tube based calibration standards - 5.3 percent; and for analyses using pressure/dilution based calibration standards - 5.6 percent.

SECTION 5

SUMMARY AND CONCLUSIONS

Cylinder gases of hydrocarbons, halocarbons, sulfurous, and oxygenated species have been used successfully as audit materials to assess the relative accuracy of gas chromatographic systems used to measure source emissions. Absolute accuracy has not been determined due to the lack of NBS standards for most of the organic gas mixtures above 1 ppm; instead an estimated interlaboratory bias has been reported for the performance audits conducted during source testing. This interlaboratory bias has been generally less than 15 percent for both low and high concentration gases (Table 3).

Of the 45 gaseous compounds studied or currently under study, 39 have demonstrated sufficient stability in cylinders to be used further as audit materials. Five compounds (ethylamine, paradichlorobenzene, cyclohexanone, 1,2-dibromoethylene, and aniline) are not recommended as audit materials for various reasons as discussed in Attachment 1. One compound (formaldehyde) was ordered but the speciality gas manufacturer indicated that cylinder gases of this compound could not be prepared. Detailed statistical analyses which separate statistical deviations from true concentration changes with time for 18 gaseous compounds have been published in a journal publication; statistical analyses for the remaining compounds will be presented in a future report.

REFERENCES

1. R. K. M. Jayanty, C. Parker, C. E. Decker, W. F. Gutknecht, J. E. Knoll and D. J. VonLehmden, "Quality Assurance for Emissions Analysis Systems," Environmental Science and Technology, 17 (6), 257-263A (1983).
2. G. B. Howe, R. K. M. Jayanty, A. V. Rao, W. F. Gutknecht, C. E. Decker and D. J. VonLehmden, "Evaluation of Selected Gaseous Halocarbons for Use in Source Test Performance Audits," J. of Air Pollution Control Association, 33 (9), 823-826 (1983).

ATTACHMENT 1

Stability Data
as of
September 1986

- 1.0 BENZENE
- 2.0 ETHYLENE
- 3.0 PROPYLENE
- 4.0 METHANE/ETHANE
- 5.0 PROPANE
- 6.0 TOLUENE
- 7.0 HYDROGEN SULFIDE
- 8.0 META-XYLENE
- 9.0 METHYL ACETATE
- 10.0 CHLOROFORM
- 11.0 CARBONYL SULFIDE
- 12.0 METHYL MERCAPTAN
- 13.0 HEXANE
- 14.0 1,2-DICHLOROETHANE
- 15.0 CYCLOHEXANE
- 16.0 METHYL ETHYL KETONE
- 17.0 METHANOL
- 18.0 1,2-DICHLOROPROPANE
- 19.0 TRICHLOROETHYLENE
- 20.0 1,1-DICHLOROETHYLENE
- 21.0 1,2-DIBROMOETHYLENE
- 22.0 PERCHLOROETHYLENE

23.0 VINYL CHLORIDE
24.0 1,3-BUTADIENE
25.0 ACRYLONITRILE
26.0 ANILINE
27.0 METHYL ISOBUTYL KETONE
28.0 CYCLOHEXANONE
29.0 PARADICHLOROBENZENE
30.0 ETHYLAMINE
31.0 FORMALDEHYDE
32.0 METHYLENE CHLORIDE
33.0 CARBON TETRACHLORIDE
34.0 FREON 113
35.0 METHYL CHLOROFORM
36.0 ETHYLENE OXIDE
37.0 PROPYLENE OXIDE
38.0 ALLYL CHLORIDE
39.0 ACROLEIN
40.0 CHLOROBENZENE
41.0 CARBON DISULFIDE
42.0 METHOD 25 GAS MIXTURE
43.0 ETHYLENE DIBROMIDE
44.0 1,1,2,2-TETRACHLOROETHANE

NOTE: PPM concentrations shown in Attachment 1 are expressed on a mole/mole basis, except for EPA Method 25 mixture which is on a mole carbon/mole basis.

1.0 BENZENE STABILITY STUDY

Cylinder No. Cylinder Construction*		1A Al	1B Al	1C Al	1D Al	1E S	1F S	1G S
Manufacturer Concentration		ppm 65.4	324	200	117	61.0	71.0	80.0
RTI Concentration	Date	7/27/77	7/27/77	7/27/77	7/27/77	2/10/78	2/10/78	2/10/78
	ppm	(79.0)	(374)	(241)	(138)	(62.0)	(71.0)	(80.0)
	Day	136	136	247	29	78	232	78
	ppm	(74.0)	(337)	(216)	(144)	(62.0)	(73.0)	(81.0)
	Day	156	156	252	157	216	385	216
	ppm	(78.0)	(350)	(215)	(134)	(61.0)	(75.0)	(81.0)
	Day	167	167	381	252	385	586	385
	ppm	(80.0)	(355)	(218)	(129)	(65.0)	(74.5)	(84.0)
	Day	630	402	**	290	722	882	504
	ppm	(77.9)	(331)		(127)	(66.9)	(75.7)	(85.4)
	Day	**	433		414	1337	1292	1292
	ppm		(343)		(127)	(55.7)	(65.7)	(74.0)
	Day		969		1247	1858	2246	2246
	ppm		(358)		(132)	(58.7)	(70.0)	(78.3)

*Al = Aluminum; S = Steel; LS = Low-Pressure Steel.

**Cylinder empty.

ANALYTICAL CONDITIONS: Flame ionization detector, 10% OV-101 on Chromosorb WHP column at 60°C.

CALIBRATION: An NBS-SRM of benzene in nitrogen is used to calibrate the detector response.

1.0 BENZENE STABILITY STUDY (Continued)

Cylinder No. Cylinder Construction*		IH S	II S	IJ S	IK S	IL S	IM S	IN S	
Manufacturer Concentration		ppm	100	139	232	265	296	326	344
RTI Concentration	Date	2/8/78	2/9/78	2/9/78	2/9/78	2/9/78	2/9/78	2/9/78	2/9/78
	ppm	(101)	(139)	(229)	(264)	(295)	(319)	(332)	
	Day	65	49	233	49	49	49	49	49
	ppm	(102)	(139)	(237)	(261)	(292)	(316)	(327)	
	Day	206	50	386	50	51	51	54	54
	ppm	(98.0)	(142)	(243)	(268)	(294)	(318)	(342)	
	Day	237	96	557	69	93	96	69	69
	ppm	(101)	(139)	(225)	(254)	(298)	(323)	(335)	
	Day	434	127	**	84	205	433	809	809
	ppm	(105)	(140)		(269)	(294)	(345)	(342)	
	Day	773	205		**	237	830	**	**
	ppm	(106)	(138)			(302)	(335)		
Day	831	505			809	1294			
ppm	(100)	(147)			(295)	(320)			
Day	1294	1293			1294	2379			
ppm	(92.0)	(128)			(290)	(310)			
Day	2380	1338			2379	2868			
ppm	(96.0)	(128)			(285)	(316)			
Day	2925	2380			2868				
ppm	(99.2)	(134)			(293)				
Day		2868							
ppm		(137)							

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Cylinder empty.

1.0 BENZENE STABILITY STUDY (Continued)

Cylinder No. Cylinder Construction*		10 S	1P S	1Q S	1R S	1S S	1T S	1U S
Manufacturer Concentration	ppm	389	8.04	9.85	9.89	9.93	10.0	10.9
RTI Concentration	Date	2/9/78	4/21/78	4/21/78	4/21/78	4/21/78	4/21/78	4/21/78
	ppm	(387)	(8.37)	(9.99)	(10.0)	(10.0)	(10.7)	(11.5)
	Day	64	4	5	4	4	25	4
	ppm	(369)	(8.33)	(9.88)	(10.1)	(10.1)	(10.2)	(10.7)
	Day	205	25	25	13	26	146	25
	ppm	(396)	(8.20)	(10.1)	(9.73)	(9.80)	(9.20)	(10.8)
	Day	809	26	332	332	56	362	332
	ppm	(396)	(8.34)	(9.71)	(9.77)	(9.50)	(9.90)	(10.7)
	Day	1294	56	**	1018	146	1222	434
	ppm	(389)	(8.19)		(9.46)	(8.90)	(9.56)	(10.9)
	Day	2247	134		1270	628	**	759
	ppm	(376)	(7.81)		(9.64)	(9.57)		(10.2)
Day	2868	434		2797	738		1222	
ppm	(386)	(8.21)		(9.75)	(9.45)		(9.69)	
Day		766			**		2175	
ppm		(7.93)					(9.90)	
Day		1222					2853	
ppm		(7.68)					(10.2)	
Day		2175						
ppm		(7.90)						
Day		2797						
ppm		(8.20)						

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Cylinder empty.

1.0 BENZENE STABILITY STUDY (Continued)

Cylinder No.		1V	1W	1X	1Y	1Z	1AA	1AB
Cylinder Construction*		S	S	S	S	S	S	S
Manufacturer	ppm	12.2	8.09	11.0	11.2	8.09	9.14	270
Concentration								
	Date	4/25/78	5/19/78	5/4/78	5/4/78	5/4/78	5/4/78	7/27/77
	ppm	(12.7)	(8.10)	(11.2)	(10.9)	(8.20)	(9.10)	(300)
	Day	1	105	132	132	132	132	29
	ppm	(12.5)	(7.70)	(10.2)	(9.90)	(7.04)	(7.80)	(319)
	Day	21	287	**	302	302	302	157
	ppm	(12.3)	(8.10)		(10.7)	(7.70)	(8.50)	(312)
RTI	Day	109	488		393	473	1005	2056
Concentration	ppm	(12.0)	(8.20)		(10.8)	(7.54)	(8.17)	(305)
	Day	358	784		2162	**	1209	**
	ppm	(12.1)	(8.30)		(10.3)		(8.42)	
	Day	755	1194		2840		2162	
	ppm	(12.0)	(7.45)		(10.6)		(8.40)	
	Day	1218	2147				2784	
	ppm	(11.7)	(7.80)				(8.72)	
	Day	2171	2769					
	ppm	(11.9)	(7.89)					
	Day	2849						
	ppm	(12.2)						

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Cylinder empty.

2.0 ETHENE (ETHYLENE) STABILITY STUDY

Cylinder No. Cylinder Construction*		2A Al	2B Al	2C Al	2D Al	2E Al	2F Al	2G Al
Manufacturer Concentration	ppm	2920	3000	4960	4970	19900	19900	4.95
RTI Concentration	Date	2/23/78	2/23/78	2/23/78	2/23/78	2/24/78	2/24/78	4/27/78
	ppm	(3070)	(3130)	(5210)	(5200)	(20400)	(20600)	(4.70)
	Day	49	49	48	48	48	48	29
	ppm	(3120)	(3180)	(5340)	(5280)	(20800)	(20800)	(4.70)
	Day	198	198	201	201	200	200	106
	ppm	(2880)	(2940)	(4660)	(4910)	(20200)	(20300)	(4.85)
	Day	809	809	809	809	808	808	741
	ppm	(3200)	(3270)	(5380)	(5340)	(18900)	(19000)	(4.62)
	Day	2291	2291	2291	2291	2290	2290	1180
	ppm	(3280)	(3350)	(5520)	(5480)	(20600)	(20700)	(5.12)
	Day	2856	2856	2856	2856	2855	2855	2224
	ppm	(3120)	(3180)	(5310)	(5270)	(20400)	(20600)	(4.50)
	Day							2804
	ppm							(4.72)

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

ANALYTICAL CONDITIONS: Flame ionization detector, Durapak n-octane on Porasil C column at 30 degrees Celsius.

CALIBRATION: An NBS-SRM of propane in nitrogen is used to calibrate the detector response.

2.0 ETHENE (ETHYLENE) STABILITY STUDY (Continued)

Cylinder No.		2H	2I	2J	2K	2L	2M	2N	
Cylinder Construction*		Al	Al	Al	Al	Al	Al	Al	
Manufacturer Concentration		ppm	10.0	15.0	19.9	300	448	603	701
RTI Concentration	Date	4/27/78	4/28/78	4/28/78	4/28/78	4/28/78	4/28/78	4/28/78	
	ppm	(9.70)	(14.4)	(19.2)	(306)	(468)	(629)	(740)	
	Day	29	28	28	33	33	34	34	
	ppm	(9.60)	(14.4)	(19.3)	(319)	(493)	(646)	(749)	
	Day	106	104	104	105	104	104	104	
	ppm	(9.90)	(14.9)	(20.3)	(312)	(473)	(636)	(737)	
	Day	740	739	739	728	740	740	740	
	ppm	(8.40)	(18.0)	(21.5)	(300)	(457)	(606)	(703)	
	Day	1180	1179	1179	2225	2225	2225	2225	
ppm	(10.0)	(14.4)	(18.9)	(291)	(435)	(583)	(678)		
Day	2224	2223	2223	2793	2793	2793	2793		
ppm	(9.50)	(14.2)	(18.9)	(290)	(437)	(590)	(684)		
Day	2587	2803	**						
ppm	(9.54)	(14.5)							
Day	2804								
		(9.76)							

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Cylinder empty.

3.0 PROPENE (PROPYLENE) STABILITY STUDY

Cylinder No. Cylinder Construction*		3A Al	3B Al	3C Al	3D Al	3E Al	3F Al	3G Al	3H Al
Manufacturer Concentration	ppm	4.94	9.91	14.8	20.0	298	446	585	683
RTI Concentration	Date	4/27/78	4/27/78	4/27/78	4/27/78	4/27/78	4/27/78	4/27/78	4/27/78
	ppm	(4.86)	(9.83)	(14.6)	(19.8)	(296)	(442)	(577)	(672)
	Day	26	26	26	27	27	27	27	27
	ppm	(4.94)	(9.85)	(14.5)	(19.0)	(286)	(428)	(560)	(655)
	Day	27	104	104	104	104	105	104	105
	ppm	(4.78)	(10.3)	(14.8)	(20.0)	(317)	(474)	(629)	(729)
	Day	104	749	749	749	750	750	750	750
	ppm	(4.98)	(9.76)	(14.8)	(20.3)	(324)	(479)	(620)	(721)
	Day	749	1250	**	2229	820	2229	2229	820
	ppm	(4.93)	(9.63)		(19.7)	(328)	(444)	(579)	(725)
	Day	2229	2229		2804	**	2794	2794	2229
	ppm	(4.80)	(9.80)		(19.8)		(449)	(589)	(676)
	Day	2601	2804						2794
	ppm	(4.75)	(9.81)						(688)
	Day	2804							
	ppm	(4.78)							

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Cylinder empty.

ANALYTICAL CONDITIONS: Flame ionization detector, Durapak n-octane on Porasil C column at 30 degrees Celsius

CALIBRATION: An NBS-SRM of propane in nitrogen is used to calibrate the detector response.

4.0 METHANE/ETHANE STABILITY STUDY

Cylinder No. Cylinder Construction*		4A Al		4B Al		4C Al		4D Al	
Audit Material**		M	E	M	E	M	E	M	E
Manufacturer Concentration		ppm							
RTI Concentration	Date	7/21/78	7/21/78	7/21/78	7/21/78	7/21/77	7/21/77	7/21/77	7/21/77
	ppm	(6210)	(773)	(8130)	(654)	(1020)	(315)	(1710)	(220)
	Day	264	163	35	35	264	163	35	29
	ppm	(5980)	(715)	(7550)	(663)	(983)	(292)	(1560)	(218)
	Day	662	264	264	163	1027	264	264	157
	ppm	(6580)	(684)	(7820)	(606)	(1290)	(283)	(1640)	(202)
	Day	2145	662	662	264	2510	1027	1027	258
	ppm	(6460)	(703)	(8590)	(577)	(1068)	(284)	(1950)	(195)
	Day	2722	2145	2145	662	3087	2510	2510	1027
	ppm	(6525)	(730)	(8430)	(598)	(1059)	(300)	(1770)	(206)
	Day		2722	2722	2145		3087	3087	2510
	ppm		(746)	(8553)	(619)		(300)	(1755)	(207)
	Day				2722				3087
	ppm				(632)				(207)

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**M = Methane; E = Ethane.

ANALYTICAL CONDITIONS: Flame ionization detector, Durapak n-octane on Porasil C column at 30 degrees Celsius.

CALIBRATION: An NBS-SRM of propane in nitrogen is used to calibrate the detector response.

5.0 PROPANE STABILITY STUDY

Cylinder No. Cylinder Construction*		5A Al	5B Al	5C Al	5D Al	5E Al	5F Al	5G Al	5H Al
Manufacturer Concentration	ppm	5.01	10.0	14.6	20.0	303	439	604	708
RTI Concentration	Date ppm	4/25/78 (4.90)	4/25/78 (9.70)	4/25/78 (14.3)	4/25/78 (19.5)	4/26/78 (304)	4/26/78 (441)	4/26/78 (615)	4/27/78 (730)
	Day ppm	24 (4.90)	24 (9.80)	25 (14.5)	25 (19.8)	24 (301)	24 (436)	27 (615)	26 (723)
	Day ppm	108 (5.10)	108 (10.1)	108 (14.9)	108 (20.3)	107 (305)	107 (440)	107 (607)	106 (710)
	Day ppm	605 (4.89)	513 (10.6)	582 (15.0)	582 (20.8)	530 (316)	530 (450)	604 (613)	603 (718)
	Day ppm	729 (5.20)	752 (10.0)	736 (14.7)	736 (20.1)	581 (316)	581 (453)	735 (628)	734 (734)
	Day ppm	**	914 (10.0)	2220 (14.8)	1252 (19.7)	735 (313)	728 (472)	2218 (607)	2218 (715)
	Day ppm		2220 (10.9)	2589 (14.8)	2220 (20.0)	752 (314)	**	2795 (617)	2794 (717)
	Day ppm		2851 (10.1)	2806 (14.6)	2806 (20.0)	913 (309)			
	Day ppm					1251 (296)			
	Day ppm					2219 (308)			
	Day ppm					2795 (308)			

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Cylinder empty.

ANALYTICAL CONDITIONS: Flame ionization detector, Durapak n-octane on Porasil C column at 30 degrees Celsius.

CALIBRATION: An NBS-SRM of propane in nitrogen is used to calibrate the detector response.

5.0 PROPANE STABILITY STUDY (Continued)

Cylinder No. Cylinder Construction*		5I Al	5J Al	5K Al	5L Al
Manufacturer Concentration	ppm	1000	2000	10,000	20,000
RTI Concentration	Date ppm	3/3/83 (1027)	3/3/83 (2100)	3/3/83 (11800)	3/3/83 (20700)
	Day ppm	452 (1070)	452 (2180)	452 (13000)	452 (21000)
	Day ppm	734 (1006)	734 (2052)	734 (13021)	734 (21302)
	Day ppm	1022 (1040)	1022 (2060)	1022 (12500)	1022 (21300)

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

6.0 TOLUENE STABILITY STUDY

Cylinder No. Cylinder Construction*		6A LS	6B LS	6C S	6D S	6E S	6F S
Manufacturer Concentration	ppm	408	606	16.2	9.11	9.00	430
RTI Concentration	Date ppm	12/6/78 (405)	12/6/78 (585)	10/3/78 (17.3)	10/3/78 (9.62)	3/29/83 (8.51)	7/1/80 (430)
	Day ppm	3 (405)	3 (579)	48 (14.9)	64 (8.50)	744 (8.04)	861 (347)
	Day ppm	86 (394)	86 (577)	365 (15.0)	66 (8.60)	1063 (9.07)	1115 (338)
	Day ppm	100 (393)	358 (615)	1373 (14.8)	160 (8.20)		1505 (427)***
	Day ppm	**	2079 (663)***	**	**		1765 (351)
	Day ppm		2338 (603)				2059 (368)
	Day ppm		2632 (618)				

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Cylinder empty.

Questionable value.

ANALYTICAL CONDITIONS: Flame ionization detector, 10% OV-101 on Chromosorb WHP column at 60 degrees Celsius.

CALIBRATION: A pressure-dilution technique is utilized for generation of a series of standards from reagent grade toluene.

6.0 TOLUENE STABILITY STUDY (Continued)

Cylinder No. Cylinder Construction*		6G Al	6H Al	6I Al	6J Al	6K LS	6L LS
Manufacturer Concentration	ppm	18.2	9.0	10.3	21.7	196	310
RTI Concentration	Date ppm	7/27/83 (16.1)	7/1/80 (8.50)	12/11/84 (9.27)	12/11/84 (20.3)	12/11/84 (183)	12/11/84 (290)
	Day ppm	383 (19.1)***	1505 (9.40)	192 (8.70)	121 (18.9)	141 (184)	141 (281)
	Day ppm	**	2064 (8.15)	440 (10.2)	440 (21.6)	436 (195)	436 (303)

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Cylinder empty.

***Questionable value.

7.0 HYDROGEN SULFIDE STABILITY STUDY

Cylinder No. Cylinder Construction*		7A Al	7B Al	7C Al	7D Al	7E Al	7F Al	7G Al
Manufacturer Concentration	ppm	399	9.15	16.7	649	6.95	6.45	671
	Date	10/1/78	7/7/78	10/1/78	10/1/78	10/1/78	10/1/78	3/2/83
	ppm	(371)	(9.73)	(16.1)	(641)	(7.05)	(4.94)	(628)
	Day	38	87	38	38	87	38	687
	ppm	(424)	(6.72)	(16.5)	(655)	(5.75)	(5.14)	(683)
	Day	111	124	111	111	124	111	833
	ppm	(414)	(7.11)	(15.7)	(690)	(5.62)	(4.81)	(654)
RTI Concentration	Day	1030	197	580	1030	197	580	1182
	ppm	(437)	(6.36)	(16.2)	(647)	(5.23)	(4.35)	(737)
	Day	2270	696	1030	**	696	1030	
	ppm	(444)	(6.23)	(17.5)		(5.14)	(3.71)	
	Day	2446	1116	2270		1116	2325	
	ppm	(401)	(8.32)	(14.5)		(5.38)	(4.3)	
	Day	2795	2399	2300		2325	2446	
	ppm	(395)	(8.00)	(15.3)		(4.6)	(4.1)	
	Day		2424	2446		2446	2762	
	ppm		(6.60)	(15.6)		(4.4)	(3.03)	
	Day		2545	2762		2762		
	ppm		(6.00)	(16.0)		(3.88)		
	Day		2848					
	ppm		(5.75)					

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Cylinder empty.

ANALYTICAL CONDITIONS: Flame photometric detector, Chromasil 330 column at 60 degrees Celsius.

CALIBRATION: A pressure-dilution technique is utilized for generation of a series of standards from pure hydrogen sulfide. A permeation tube is used for generation of calibration mixtures for lower level (<100 ppm) cylinder analyses.

ANALYTICAL PROBLEMS: Only a Teflon® column and Teflon® sample loop should be used. The air-to-hydrogen ratio is critical to the sensitivity of the FPD.

7.0 HYDROGEN SULFIDE STABILITY STUDY (Continued)

Cylinder No. Cylinder Construction*		7H	7I	7J	7K	7L	7M	7N	7O
		Al	Al	Al	Al	Al	Al	Al	Al
Manufacturer Concentration	ppm	20.77	29.27	39.14	97.31	206.3	323.2	417	503.2
RTI Concentration	Date	1/17/85	1/17/85	1/17/85	1/17/85	1/16/85	1/16/85	1/16/85	1/16/85
	ppm	(17.7)	(22.6)	(31.6)	(83.7)	(200)	(291)	(398)	(489)
	Day	25	25	25	146	147	147	147	147
	ppm	(20.6)	(30.4)	(42.4)	(92.1)	(210)	(320)	(415)	(514)
	Day	146	146	146	495	496	496	496	496
	ppm	(21.0)	(30.5)	(40.5)	(97.8)	(198)	(306)	(420)	(537)
	Day	462	462	462					
	ppm	(21.2)	(29.0)	(39.8)					

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

8.0 1,3-DIMETHYLBENZENE (M-XYLENE) STABILITY STUDY

Cylinder No. Cylinder Construction*		8A LS	8B LS	8C S	8D S	8E LS	8F LS	8G Al
Manufacturer Concentration	ppm	405	613	17.3	7.33	600.5	351.4	12.11
RTI Concentration	Date	10/5/78	10/5/78	10/5/78	10/5/78	6/7/85	6/7/85	6/7/85
	ppm	(480)	(720)	(16.6)	(6.20)	(596)	(362)	(11.5)
	Day	63	63	63	63	257	257	257
	ppm	(445)	(676)	(17.2)	(6.81)	(552)	(344)	(11.1)
	Day	158	158	166	166			
	ppm	(425)	(656)	(20.8)	(6.82)			
	Day	412	606	302	1036			
	ppm	(487)	(760)	(16.4)	(5.66)			
	Day	606	2140	1036	2694			
	ppm	(507)	(598)	(19.0)	(4.39)			
		**	**	**				

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Cylinder empty.

CALIBRATION: A pressure-dilution technique is used for generation of a series of standards from reagent grade m-xylene.

ANALYTICAL CONDITIONS: Flame ionization detector, 10% OV-101 on Chromosorb WHP column at 60, 120 or 140 degrees Celsius.

9.0 METHYL ESTER ACETIC ACID (METHYL ACETATE) STABILITY STUDY

Cylinder No. Cylinder Construction*		9A S	9B S	9C S	9D S
Manufacturer	ppm	326	455	6.84	17.2
Concentration					
	Date	10/13/78	10/13/78	10/13/78	10/13/78
	ppm	(271)	(428)	(5.29)	(12.9)**
	Day	230	230	230	230
	ppm	(340)	(437)	(4.86)	(12.5)**
RTI	Day	286	286	286	286
Concentration	ppm	(324)	(442)	(5.02)	(11.8)**
	Day	629	629	630	630
	ppm	(348)	(479)	(5.88)	(12.5)**
	Day	2442	2442	2442	2442
	ppm	(336)	(470)	(5.32)	(17.2)
	Day	2742	2742	2742	2742
	ppm	(320)	(437)	(5.89)	(16.5)

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Questionable value.

ANALYTICAL CONDITIONS: Flame ionization detector, 10% OV-275 on Chromosorb WHP column at 50 degrees Celsius.

CALIBRATION: A pressure-dilution technique is utilized for generation of a series of standards from reagent grade methyl acetate.

10.0 TRICHLOROMETHANE (CHLOROFORM) STABILITY STUDY

Cylinder No. Cylinder Construction*		10A S	10B S	10C S	10D S	10E Al	10F Al
Manufacturer	ppm	520	348	8.70	16.9	9.805	21.96
Concentration							
RTI Concentration	Date	10/17/78	10/17/78	10/17/78	10/17/78	1/10/86	1/10/86
	ppm	(529)	(345)	(8.08)	(17.6)	(8.92)	(21.1)
	Day	161	161	161	161		
	ppm	(515)	(351)	(7.39)	(16.5)		
	Day	256	256	256	256		
	ppm	(514)	(340)	(7.50)	(16.2)		
	Day	553	975	553	553		
	ppm	(531)	(325)	(8.11)	(16.5)		
	Day	**	2422	2422	2422		
	ppm		(333)	(4.26)	(14.9)		
	Day		2642	2642	2642		
	ppm		(326)	(4.52)	(15.0)		

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Cylinder empty.

ANALYTICAL CONDITIONS: Flame ionization detector, 10% OV-101 on Chromosorb WHP column at 50 or 10 degrees Celsius.

CALIBRATION: A pressure-dilution technique is utilized for generation of a series of standards from reagent grade chloroform.

11.0 CARBONYL SULFIDE STABILITY STUDY

Cylinder No. Cylinder Construction*		11A S	11B S	11C S	11D S	11E AL	11F AL
Manufacturer Concentration	ppm	251	100	9.96	7.03	9.54	101
RTI Concentration	Date	11/3/78	11/3/78	11/3/78	11/3/78	9/18/81	9/18/81
	ppm	(276)	(109)	(9.10)	(6.81)	(12.9)	(111)
	Day	78	78	78	78	35	35
	ppm	(281)	(111)	(8.66)	(6.48)	(12.5)	(117)
	Day	185	185	185	185	222	**
	ppm	(275)	(95.0)	(8.23)	(6.41)	(9.08)	
		**	**	**	**	**	

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Cylinder empty.

ANALYTICAL CONDITIONS: Flame photometric detector, Carbopack B column at 50 degrees Celsius or Chromosil 330 column at 60 degrees Celsius.

CALIBRATION: A pressure-dilution technique is used for generation of a series of standards from pure carbonyl sulfide.

ANALYTICAL PROBLEMS: Only a Teflon® column and Teflon® sample loop should be used. The air-to-hydrogen ratio is critical to the sensitivity of the FPD.

11.0 CARBONYL SULFIDE STABILITY STUDY (Continued)

Cylinder No. Cylinder Construction*		11G Al	11H Al	11I Al	11J Al	11K Al
Manufacturer Concentration	ppm	99.2	225	414	10.71	101
RTI Concentration	Date	1/11/85	1/11/85	1/11/85	1/11/85	1/11/85
	ppm	(101)	(228)	(423)	(9.3)	(99.0)
	Day	150	150	150	150	150
	ppm	(96.5)	(199)	(404)	(10.0)	(98.0)
	Day	517	517	517	517	517
	ppm	(105)	(205)	(420)	(11.7)	(105)

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

12.0 METHANEITHIOL (METHYL MERCAPTAN) STABILITY STUDY

Cylinder No. Cylinder Construction*		12A Al	12B Al	12C Al	12D Al
Manufacturer Concentration	ppm	8.03	10.0	3.55	4.22
RTI Concentration	Date	1/24/79	1/24/79	1/24/79	1/24/79
	ppm	(5.66)	(7.94)	(3.65)	(4.23)
	Day	104	104	104	104
	ppm	(5.60)	(8.10)	(3.50)	(4.76)
	Day	139	139	139	139
	ppm	(5.65)	(7.90)	(3.56)	(4.54)
	Day	985	985	985	**
	ppm	(5.40)	(8.42)	(3.64)	
	Day	2194	2194	2194	
	ppm	(5.45)	(8.00)	(3.80)	
	Day	2331	2331	2331	
	ppm	(4.70)	(8.00)	(3.40)	
	Day	2690	2690	2690	
	ppm	(5.70)	(9.84)	(3.73)	

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Cylinder empty.

ANALYTICAL CONDITIONS: Flame photometric detector, Carbowack B column at 50 degrees Celsius or Chromosil 330 column at 60 degrees Celsius.

CALIBRATION: Reagent grade pure "methyl mercaptan" gas is initially used as a standard. Dilutions are made in a Tedlar bag for generation of series of standards for calibration. A permeation tube is used for generation of calibration mixtures for the last three analyses.

ANALYTICAL PROBLEMS: Only a Teflon® column and Teflon® sampling loop should be used. The air-to-hydrogen ratio is critical to the sensitivity of the FPD.

13.0 HEXANE STABILITY STUDY

Cylinder No. Cylinder Construction*		13A LS	13B LS	13C Al	13D Al	13E Al
Manufacturer	ppm	1975	2973	30.6	79.2	80.0
RTI Concentration	Date	2/6/79	2/6/79	2/6/79	2/6/79	3/25/83
	ppm	(2170)	(3070)	(30.8)	(82.2)	(83.2)
	Day	6	6	296	296	376
	ppm	(1980)	(2860)	(30.1)	(81.0)	(88.2)
	Day	337	338	337	337	1117
	ppm	(2070)	(2950)	(30.6)	(81.3)	(92.1)
	Day	469	469	469	469	
	ppm	(1990)	(3080)	(32.0)	(79.8)	
	Day	1886	1886	523	835	
	ppm	(1990)	(2980)	(30.0)	(80.2)	
	Day	2586	**	835	1247	
	ppm	(2139)		(30.2)	(82.7)	
	Day			1886	**	
	ppm			(32.8)		
	Day			2586		
	ppm			(34.8)		

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Cylinder empty.

ANALYTICAL CONDITIONS: Flame ionization detector, 10% OV-101 on Chromosorb WHP column at 60 or 100 degrees Celsius.

CALIBRATION: A pressure-dilution technique is utilized for making a series of standards from reagent grade hexane.

14.0 1,2-DICHLOROETHANE STABILITY STUDY

Cylinder No. Cylinder Construction*		14A Al	14B Al	14C Al	14D Al	14E Al	14F Al	14G Al	14H Al
Manufacturer Concentration	ppm	14.4	9.64	100	526	6.92	12.5	97.9	439
RTI Concentration	Date	1/19/79	1/19/79	1/19/79	1/19/79	4/5/79	4/5/79	4/5/79	4/5/79
	ppm	(14.1)	(9.20)	(96.2)	(498)	(10.0)	(15.2)	(102)	(463)
	Day	58	58	58	58	30	30	30	30
	ppm	(15.2)	(10.8)	(103)	(534)	(9.42)	(14.7)	(105)	(451)
	Day	155	155	155	155	69	69	69	69
	ppm	(14.9)	(10.0)	(98.2)	(524)	(9.30)	(14.3)	(99.0)	(462)
	Day	811	811	501	501	586	811	425	589
	ppm	(14.2)	(9.56)	(87.3)	(592)**	(9.14)	(14.5)	(87.3)	(432)
	Day	835	835	920	920	811	835	844	697
	ppm	(13.5)	(9.19)	(102)	(502)	(9.70)	(13.8)	(101)	(451)
Day	1964	1964	1964	1964	835	1888	1888	844	
ppm	(13.9)	(9.68)	(94.9)	(477)	(9.16)	(13.9)	(92.4)	(453)	
Day	2333	2333	2333	2333	2247	2247	2247	1888	
ppm	(14.1)	(9.30)	(96.7)	(496)	(9.32)	(14.3)	(96.0)	(416)	
Day	2546	2546	2546	2546	2470	2470	2470	2247	
ppm	(13.6)	(8.65)	(97.5)	(490)	(8.85)	(13.8)	(97.2)	(427)	
Day								2470	
ppm								(422)	

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Questionable value.

ANALYTICAL CONDITIONS: Flame ionization detector, 10% OV-101 on Chromosorb WHP column at 100 degrees Celsius.

CALIBRATION: A pressure-dilution technique is utilized for making a series of standards from reagent grade 1,2-dichloroethane.

15.0 CYCLOHEXANE STABILITY STUDY

Cylinder No.		15A
Cylinder Construction*		Al
Manufacturer Concentration	ppm	99.1
RTI Concentration	Date	3/19/79
	ppm	(106)
	Day	147
	ppm	(93.4)
	Day	394
	ppm	(99.0)
	Day	926
	ppm	(102)
	Day	1966
	ppm	(95.9)
	Day	2559
	ppm	(100)

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

ANALYTICAL CONDITIONS: Flame ionization detector, 10% OV-101 on Chromosorb WHP column at 100 degrees Celsius.

CALIBRATION: A pressure-dilution technique is used for making a series of standards from reagent grade cyclohexane.

16.0 2-BUTANONE (METHYL ETHYL KETONE) STABILITY STUDY

Cylinder No.		16A
Cylinder Construction*		S
Manufacturer	ppm	43.7
Concentration		
RTI Concentration	Date	5/23/79
	ppm	(42.3)
	Day	28
	ppm	(40.0)
	Day	58
	ppm	(39.9)
	Day	380
	ppm	(44.5)
	Day	653
	ppm	(38.7)
	Day	1847
	ppm	(40.4)
	Day	2520
	ppm	(45.0)

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

ANALYTICAL CONDITIONS: Flame ionization detector, Chromosorb 101 column at 180 degrees Celsius.

CALIBRATION: A pressure-dilution technique is utilized for making a series of standards from reagent grade methyl ethyl ketone.

17.0 METHANOL STABILITY STUDY

Cylinder No.		17A
Cylinder Construction*		Al
Manufacturer	ppm	50.0
Concentration		
RTI Concentration	Date	5/17/79
	ppm	(58.8)
	Day	21
	ppm	(52.3)
	Day	51
	ppm	(51.1)
	Day	196
	ppm	(55.2)
	Day	2020
	ppm	(48.8)
	Day	2224
	ppm	(45.8)
	Day	2660
	ppm	(56.8)

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

ANALYTICAL CONDITIONS: Flame ionization detector, Chromosorb 101 column at 50 degrees Celsius or 0.2% Carbowax 1500 plus 0.1% SP-2100 on Carbowax C at 60 degrees Celsius.

CALIBRATION: A pressure-dilution technique is utilized for making a series of standards from reagent grade methanol.

18.0 1,2-DICHLOROPROPANE (PROPYLENE DICHLORIDE) STABILITY STUDY

Cylinder No. Cylinder Construction*		18A Al	18B Al	18C Al	18D Al
Manufacturer Concentration	ppm	7.07	14.6	476	664
RTI Concentration	Date	7/10/79	7/10/79	7/10/79	7/10/79
	ppm	(6.06)	(15.6)	(496)	(685)
	Day	28	28	28	28
	ppm	(5.52)	(16.4)	(455)	(621)
	Day	48	48	48	48
	ppm	(5.94)	(15.0)	(480)	(675)
	Day	497	749	372	372
	ppm	(6.03)	(16.3)	(497)	(685)
	Day	749	1793	1793	1793
	ppm	(5.59)	(12.1)	(402)	(557)
	Day	1793	1845	1845	1845
	ppm	(3.12)	(13.2)	(424)	(574)
	Day	1845	2155	2155	2155
	ppm	(3.86)	(13.3)	(441)	(594)
	Day	2155	2387	2387	2387
	ppm	(3.49)	(12.9)	(429)	(576)
	Day	2387			
	ppm	(3.25)			

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

ANALYTICAL CONDITIONS: Flame ionization detector, 10% OV-101 on Chromosorb WHP column at 100 degrees Celsius.

CALIBRATION: A pressure-dilution technique is utilized for making a series of standards from reagent grade 1,2-dichloropropane.

19.0 TRICHLOROETHENE (TRICHLOROETHYLENE) STABILITY STUDY

Cylinder No. Cylinder Construction*		19A Al	19B Al	19C Al	19D Al
Manufacturer Concentration	ppm	9.23	14.7	100	505
RTI Concentration	Date	5/24/79	5/24/79	5/24/79	5/24/79
	ppm	(9.58)	(14.3)	(102)	(506)
	Day	77	77	77	77
	ppm	(10.2)	(15.1)	(103)	(503)
	Day	92	92	92	92
	ppm	(9.78)	(14.9)	(100)	(499)
	Day	683	683	810	810
	ppm	(9.03)	(13.6)	(105)	(522)
	Day	820	820	820	820
	ppm	(8.91)	(13.5)	(94.6)	(490)
	Day	1853	1853	1853	1853
	ppm	(9.40)	(14.0)	(105)	(523)
	Day	2493	2493	2493	2493
	ppm	(10.2)	(15.5)	(101)	(494)

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

ANALYTICAL CONDITIONS: Flame ionization detector, 10% OV-101 on Chromosorb WHP column at 100 degrees Celsius.

CALIBRATION: A pressure-dilution technique is used for making a series of standards from reagent grade trichloroethylene.

20.0 1,1-DICHLOROETHYLENE (VINYLIDENE CHLORIDE) STABILITY STUDY

Cylinder No. Cylinder Construction*		20A Al	20B Al	20C Al	20D Al
Manufacturer	ppm	9.58	14.8	96.8	490
Concentration					
	Date	6/1/79	6/1/79	6/1/79	6/1/79
	ppm	(10.3)	(15.6)	(101)	(524)
	Day	35	35	35	35
	ppm	(9.90)	(15.1)	(99.0)	(510)
	Day	62	62	62	62
	ppm	(10.1)	(15.5)	(102)	(505)
RTI	Day	404	404	817	404
Concentration	ppm	(11.5)**	(17.1)**	(94.0)	(498)
	Day	818	818	1831	1831
	ppm	(9.00)	(14.2)	(98.4)	(488)
	Day	1831	1831	2190	2190
	ppm	(9.00)	(13.2)	(94.7)	(479)
	Day	2190	2190	2490	2490
	ppm	(8.78)	(14.1)	(97.4)	(478)
	Day	2490	2490		
	ppm	(9.87)	(15.2)		

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Questionable value.

ANALYTICAL CONDITIONS: Flame ionization detector, 10% OV-101 on Chromosorb WHP column at 100 degrees Celsius or 10% SP-2100 on Supelcoport column at 100 degrees Celsius.

CALIBRATION: A pressure-dilution technique is utilized for making a series of standards from reagent grade 1,1-dichloroethene.

21.0 1,2-DIBROMOETHYLENE STABILITY STUDY

Cylinder No. Cylinder Construction*		21A LS	21B LS	21C LS	21D LS
Manufacturer Concentration	ppm	10.0	14.9	99.9	301
RTI Concentration	Date ppm	6/18/79 (7.90)	6/18/79 (12.2)	6/1/79 (110)	6/18/79 (265)
	Day ppm	61 (7.80)	61 (12.0)	61 (107)	61 (266)
	Day ppm	89 (7.40)	89 (11.6)	89 (105)	89 (257)
	Day ppm	722 (7.72)	772 (8.02)	787 (99.2)	643 (309)
		**	**	**	**

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Cylinders returned due to partial conversion to an unknown compound.

ANALYTICAL CONDITIONS: Flame ionization detector, 10% OV-101 on Chromosorb WHP column at 100 degrees Celsius.

CALIBRATION: Reagent grade "1,2-Dibromoethylene" pure liquid is used as a standard. Pressure-dilution technique is utilized for making series of standards for calibration.

ANALYTICAL PROBLEMS: The gas mixtures and the calibration standards contain substantial amounts of both the cis and the trans isomers of 1,2-Dibromoethylene. The first three sets of analyses are questionable because only one isomer was measured during the calibrations and cylinder analyses. During the GC analyses on Day 1864, it was found that dibromoethylene partially converted to an unknown compound. Hence, dibromoethylene is not practical as an audit material.

22.0 TETRACHLOROETHENE (PERCHLOROETHYLENE) STABILITY STUDY

Cylinder No. Cylinder Construction*		22A S	22B S	22C LS	22D LS
Manufacturer Concentration	ppm	7.98	13.0	487	629
RTI Concentration	Date	7/6/79	7/6/79	7/6/79	7/6/79
	ppm	(8.40)	(15.0)	(419)	(624)
	Day	35	35	35	35
	ppm	(7.97)	(14.9)	(453)	(642)
	Day	52	52	52	52
	ppm	(7.92)	(14.7)	(440)	(619)
	Day	376	376	677	677
	ppm	(7.94)	(14.5)	(361)	(542)
	Day	1818	1818	713	713
	ppm	(6.88)	(13.7)	(387)	(571)
	Day	2162	2162	1818	1818
	ppm	(6.88)	(13.3)	(349)	(557)
	Day	2440	2440	2162	2162
	ppm	(7.83)	(13.5)	(353)	(564)
	Day			2450	2450
	ppm			(357)	(551)

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

ANALYTICAL CONDITIONS: Flame ionization detector, 10% OV-101 on Chromosorb WHP column at 50 or 100 degrees Celsius.

CALIBRATION: A pressure-dilution technique is utilized for making a series of standards from reagent grade perchloroethylene. An NBS-SRM of perchloroethylene in nitrogen is used to calibrate the detector response for analysis of lower concentration cylinders.

23.0 CHLOROETHENE (VINYL CHLORIDE) STABILITY STUDY

Cylinder No. Cylinder Construction*		23A S	23B S	23C S	23D S	23E S	23F S	23G S	23H S	23I S
Manufacturer	ppm	5.94	8.00	8.03	8.52	20.0	20.1	30.0	30.3	7.98
Concentration										
RTI Concentration	Date	10/1/79	10/1/79	10/1/79	10/1/79	10/1/79	10/1/79	10/1/79	10/1/79	10/1/79
	ppm	(5.87)	(7.71)	(7.82)	(7.85)	(19.7)	(20.1)	(29.6)	(29.8)	(7.31)
	Day	18	18	18	18	18	18	18	18	18
	ppm	(5.74)	(7.50)	(7.45)	(7.61)	(19.1)	(19.3)	(28.3)	(28.7)	(7.12)
	Day	700	**	700	700	700	700	700	700	700
	ppm	(6.60)		(8.44)	(8.41)	(20.7)	(20.9)	(29.4)	(29.4)	(8.39)
	Day	1812		1812	1812	1812	1812	1812	1812	1812
	ppm	(6.10)		(8.10)	(8.15)	(20.3)	(20.6)	(30.3)	(30.6)	(7.75)
	Day	2524		2524	2524	2524	2524	2524	2524	
	ppm	(6.09)		(8.05)	(8.13)	(20.4)	(20.6)	(30.3)	(31.1)	

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Cylinder empty.

ANALYTICAL CONDITIONS: Flame ionization detector, 0.4% Carbowax 1500 on Carbopack C at 50 degrees Celsius.

CALIBRATION: Vinyl chloride permeation tube purchased from Metronics is used for calibration. Permeation tube is maintained at 30°C.

24.0 1,3-BUTADIENE STABILITY STUDY

Cylinder No. Cylinder Construction*		24A S	24B Al	24C Al	24D Al
Manufacturer Concentration	ppm	22.6	52.83	31.90	13.25
RTI Concentration	Date	3/21/80	2/12/86	2/12/86	2/12/86
	ppm	(20.9)	(52.9)	(32.3)	(13.4)
	Date	95			
	ppm	(23.1)			
	Day	480			
	ppm	(24.0)			
	Day	1718			
	ppm	(22.9)			
		**			

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Cylinder empty.

ANALYTICAL CONDITIONS: Flame ionization detector, 0.1% SP-1000 on Carbopack C column at 90 degrees Celsius or 10% OV-101 on Chromosorb WHP column at 60 degrees Celsius.

CALIBRATION: A pressure-dilution technique is utilized for making a series of standards from pure 1,3-butadiene.

25.0 2-PROPENENITRILE (ACRYLONITRILE) STABILITY STUDY

Cylinder No. Cylinder Construction*		25A LS	25B LS	25C LS	25D LS	25E AL	25F AL	25G Al	25H Al
Manufacturer Concentration	ppm	20.1	348	11.7	638	400	10.0	17.96	22.32
RTI Concentration	Date ppm	7/24/79 (14.6)	7/24/79 (411)	7/24/79 (6.38)	7/24/79 (678)	11/8/82 (413)	11/18/82 (10.8)	1/23/86 (15.0)	1/23/86 (20.2)
	Day ppm	185 (12.7)	185 (416)	185 (3.35)	185 (699)	134 (410)	139 (11.7)		
	Day ppm	349 (13.2)	349 (441)	349 (2.87)	349 (703)	787 (421)	787 (10.8)		
	Day ppm	841 (9.96)	841 (397)	841 (4.05)	841 (667)	1172 (424)	1162 (9.14)		
	Day ppm	**	**	**	**				
	Day ppm								

*Al = Aluminum; S = Steel; LS= Low Pressure Steel.

**Cylinder empty.

ANALYTICAL CONDITIONS: Flame ionization detector, 4% Carbowax 20M on Carbopack B at 50 or 150 degrees Celsius.

CALIBRATION: A pressure-dilution technique is used to make a series of standards from reagent grade acrylonitrile.

ANALYTICAL PROBLEMS: The large changes noted at the low concentration levels are, at least in part, a result of difficulty in making precise measurements at these levels.

26.0 ANILINE STABILITY STUDY

Cylinder No.	26A	26B
Cylinder Construction*	Al	Al
Manufacturer Concentration	11.3	18.4
RTI Analysis	See Analytical Problems	

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

ANALYTICAL CONDITIONS: Flame ionization detector, 10% OV-101 on Chromosorb WHP column at 250 degrees Celsius.

CALIBRATION: Reagent grade "Aniline" pure liquid is used as a standard. "Glass bulb" dilution technique is utilized for making series of standards for calibration.

ANALYTICAL PROBLEMS: Because aniline has an extremely high boiling point (186°C), special handling would be required to measure this compound. A completely heated system for sampling in the vapor phase and for preparing standards would be required. Temperature-dependent condensation in the cylinder and the regulator causes the amount of aniline which is delivered by the cylinder to vary. As a result, aniline is not considered to be practical as an audit material.

27.0 4-METHYL-2-PENTANONE (METHYL ISOBUTYL KETONE) STABILITY STUDY

Cylinder No.		27A	27C
Cylinder Construction*		Al	Al
Manufacturer		9.51	72.9
Concentration			
RTI Concentration	Date	12/18/80	7/8/81
	ppm	(10.2)	(75.4)
	Day	27	See Analytical
	ppm	(10.6)	Problems
	Day	83	
	ppm	(9.53)	
	Day	202	
	ppm	(9.49)	
	Day	1275	
	ppm	(8.40)	
	Day	1643	
	ppm	(10.3)	
	Day	1946	
	ppm	(10.2)	

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

ANALYTICAL CONDITIONS: Flame ionization detector, 0.1% SP-1000 on Carbowack C column at 180 degrees Celsius.

CALIBRATION: A pressure-dilution technique is utilized for making a series of standards from reagent grade methyl isobutyl ketone.

ANALYTICAL PROBLEMS: Methyl isobutyl ketone at high concentrations is not practical as an audit material because pressurization of the cylinder above approximately 200 psi results in condensation of the analyte.

28.0 CYCLOHEXANONE STABILITY STUDY

Cylinder No.		28A	28B
Cylinder Construction*		Al	Al
Manufacturer			
Concentration		10.1	19.0
		Date	12/11/80
		ppm	(8.19)
			12/11/80
			(25.5)
RTI			
Analysis		Day	85
		ppm	(3.26)
			85
			(17.1)
See Analytical Problems.			

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

ANALYTICAL CONDITIONS: Flame ionization detector, 10% SP-1000 on Supelcoport column at 200 degrees Celsius.

CALIBRATION: Reagent grade "Cyclohexanone" liquid is used as a standard. Pressure-dilution technique is used for making series of standards for calibration.

ANALYTICAL PROBLEMS: The analysis of cyclohexanone gas is dependent on the temperatures of the cylinder and the regulator and on the length of the sampling line between the regulator and the gas chromatograph. The concentration in the cylinder decreases with time. Therefore, cyclohexanone is not practical as an audit material.

29.0 PARADICHLOROBENZENE STABILITY STUDY

Cylinder No.	29A	29B
Cylinder Construction*	S	S
Manufacturer	ppm	
Concentration	15.6	38.1
RTI Analysis	See Analytical Problems	

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

ANALYTICAL CONDITIONS: Flame ionization detector, 10% SP-1000 on Supelcoport column at 200 degrees Celsius.

CALIBRATION: Reagent grade "Paradichlorobenzene" is used as a standard. "Glass bulb" technique is used for making series of standards for calibration.

ANALYTICAL PROBLEMS: The stability study for this compound was terminated because of analytical difficulties and because the cylinder pressure was less than 200 psig. Paradichlorobenzene is a solid at room temperature with a melting point of 54°C. Condensation in the cylinder, regulator and sampling lines was extreme. Paradichlorobenzene is not practical as an audit material.

30.0 ETHYLAMINE STABILITY STUDY

Cylinder No.		30A	30B
Cylinder Construction*		S	S
Manufacturer	ppm	10	20
Concentration			
RTI			
Analysis		See Analytical Problems	

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

ANALYTICAL CONDITIONS: Flame ionization detector, 10% OV-101 on Chromosorb WHP column at 250 degrees Celsius.

CALIBRATION: Reagent grade "Ethylamine" liquid is used as a standard. "Glass bulb" technique is utilized for making series of standards for calibration.

ANALYTICAL PROBLEMS: Because of vapor pressure considerations, the cylinders could not be fully pressurized. The pressure in the cylinder is less than 200 psi. A completely heated system for sampling in the vapor phase and for preparing standards would be required. Temperature-dependent condensation in the cylinder and the regulator causes the amount of ethylamine which is delivered by the cylinder to vary. As a result of these problems, ethylamine is not considered to be practical as an audit material.

31.0 FORMALDEHYDE STABILITY STUDY

RTI Requested Concentration	ppm	10	20
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The speciality gas supplier indicated that they could not make gas mixtures containing formaldehyde.

32.0 DICHLOROMETHANE (METHYLENE CHLORIDE) STABILITY STUDY

Cylinder No. Cylinder Construction*		32A Al	32B Al	32C Al
Manufacturer Concentration	ppm	10.2	1.247	6.132
RTI Concentration	Date ppm	3/5/82 (10.8)	1/27/86 (1.13)	1/27/86 (6.01)
	Day ppm	31 (10.8)		
	Day ppm	70 (10.6)		
	Day ppm	96 (11.2)		
	Day ppm	124 (11.4)		
	Day ppm	160 (10.9)		
	Day ppm	278 (10.2)		
	Day ppm	381 (9.70)		
	Day ppm	843 (9.20)**		
	Day ppm	1198 (11.5)		
	Day ppm	1449 (10.4)		

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Questionable value.

ANALYTICAL CONDITIONS: Flame ionization detector, 20 ft. x 1/8" SS column packed with 10% SP-1000 on 80/100 Supelcoport at 100 degrees Celsius.

CALIBRATION: A pressure-dilution technique is utilized for making a series of standards from reagent grade methylene chloride.

33.0 TETRACHLOROMETHANE (CARBON TETRACHLORIDE) STABILITY STUDY

Cylinder No. Cylinder Construction*		33A AL	33B AL	33C AL	33D AL
Manufacturer Concentration	ppm	11.3	23.26	5.815	18.57
RTI Concentration	Date ppm	3/4/82 (12.7)	1/16/86 (21.8)	1/16/86 (5.88)	1/16/86 (18.1)
	Day ppm	74 (11.7)			
	Day ppm	74 (10.2)			
	Day ppm	98 (11.1)			
	Day ppm	124 (10.6)			
	Day ppm	161 (10.2)			
	Day ppm	382 (10.5)			
	Day ppm	832 (9.60)**			
	Day ppm	1199 (12.2)			
	Day ppm	1414 (10.6)			

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Questionable value.

ANALYTICAL CONDITIONS: Flame ionization detector, 20 ft. x 1/8" SS column packed with 10% SP-1000 on 80/100 Supelcoport at 100 degrees Celsius.

CALIBRATION: A pressure-dilution technique is utilized for making a series of standards from reagent grade carbon tetrachloride.

34.0 1,1,2-TRICHLORO-1,2,2-TRIFLUOROETHANE (FREON 113) STABILITY STUDY

Cylinder No. Cylinder Construction*		34A Al
Manufacturer Concentration	ppm	10.4
RTI Concentration	Date ppm	3/3/82 (10.8)
	Day ppm	34 (10.1)
	Day ppm	70 (10.0)
	Day ppm	70 (9.60)
	Day ppm	98 (10.0)
	Day ppm	125 (10.0)
	Day ppm	162 (10.3)
	Day ppm	384 (9.80)
	Day ppm	857 (11.0)
	Day ppm	1200 (8.79)
	Day ppm	1506 (10.0)

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

ANALYTICAL CONDITIONS: Flame ionization detector, 20 ft.
x 1/8" SS column packed with 10% SP-1000 on 80/100
Supelcoport at 100 degrees Celsius.

CALIBRATION: A pressure-dilution technique is utilized for
making a series of standards from reagent grade Freon 113.

35.0 1,1,1-TRICHLOROETHANE (METHYL CHLOROFORM) STABILITY STUDY

Cylinder No.		35A
Cylinder Construction*		Al
Manufacturer Concentration	ppm	10.2
RTI Concentration	Date	3/2/82
	ppm	(10.3)
	Day	70
	ppm	(11.8)
	Day	99
	ppm	(10.7)
	Day	136
	ppm	(10.6)
	Day	161
	ppm	(10.0)
	Day	381
	ppm	(10.4)
	Day	858
	ppm	(10.0)
	Day	1514
	ppm	(10.7)

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

ANALYTICAL CONDITIONS: Flame ionization detector, 20 ft. x 1/8" SS column packed with 10% SP-1000 on 80/100 Supelcoport at 100 degrees Celsius.

CALIBRATION: A pressure-dilution technique is utilized for making a series of standards from reagent grade methyl chloroform.

36.0 1,2-EPOXYETHANE (ETHYLENE OXIDE) STABILITY STUDY

Cylinder No. Cylinder Construction*		36A Al	36B Al	36C Al	36D Al	36E Al
Manufacturer Concentration	ppm	10.0	1.0	4.5	14	19.0
RTI Concentration	Date	3/12/82	9/16/85	9/16/85	9/16/85	9/16/85
	ppm	(11.2)	(1.19)	(4.75)	(14.3)	(18.6)
	Day	73	78	78	78	78
	ppm	(9.60)	(0.868)	(4.35)	(14.2)	(17.7)
	Day	88				
	ppm	(9.80)				
	Day	122				
	ppm	(9.60)				
	Day	157				
	ppm	(9.80)				
	Day	1012				
	ppm	(9.70)				
	Day	1362				
	ppm	(9.09)				

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

ANALYTICAL CONDITIONS: Flame ionization detector, 6 ft. x 1/8" SS column packed with 80/100 mesh Porapak QS at 150 degrees Celsius.

CALIBRATION: Ethylene oxide permeation tube is used for GC-FID calibration. Permeation tube is maintained at 30 degrees Celsius.

37.0 1,2-EPOXYPROPANE (PROPYLENE OXIDE) STABILITY STUDY

Cylinder No. Cylinder Construction*		37A Al	37B Al
Manufacturer	ppm	9.48	96.0
Concentration			
RTI Concentration	Day	8/4/82	8/4/82
	ppm	(12.3)	(89.5)
	Day	55	55
	ppm	(11.8)	(86.9)
	Day	76	76
	ppm	(10.6)	(83.6)
	Day	743	121
	ppm	(8.10)**	(90.8)
	Day	844	743
	ppm	(9.24)	(75.7)**
	Day	1057	844
	ppm	(9.65)	(82.8)**
	Day	1357	1057
	ppm	(10.2)	(91.7)
	Day		1357
	ppm		(95.2)

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Questionable value.

ANALYTICAL CONDITIONS: Flame ionization detector, 6 ft. x 1/8" SS column packed with 80/100 mesh Porapak Q5 at 150 degrees Celsius.

CALIBRATION: A pressure-dilution technique is utilized for making a series of standards from reagent grade propylene oxide.

38.0 3-CHLOROPROPENE (ALLYL CHLORIDE) STABILITY STUDY

Cylinder No. Cylinder Construction*		38A S	38B S	38C S	38D S
Manufacturer Concentration	ppm	10.2	99.5	8.7	92.4
RTI Concentration	Date	8/13/82**	8/13/82**	4/24/85**	4/30/85
	ppm	(11.6)	(124)	(8.99)	(95.7)
	Day	75	74	364	358
	ppm	(5.25)	(87.2)	(6.14)	(94.2)
	Day	110	110		
	ppm	(5.08)	(87.7)		
	Day	167	167		
	ppm	(5.36)	(83.4)		
	Day	727	727		
	ppm	(4.53)	(53.6)		
		***	***		

* Al = Aluminum; S = Steel; LS = Low Pressure Steel.

** Initial analysis was questionable

*** Returned due to impurities.

ANALYTICAL CONDITIONS: Flame ionization detector, 20 ft. x 1/8" SS column packed with 10 % SP-1000 on Supelcoport at 100 degrees Celsius.

CALIBRATION: A pressure-dilution technique is utilized for making a series of standards from reagent grade allyl chloride.

39.0 PROPENAL (ACROLEIN) STABILITY STUDY

Cylinder No. Cylinder Construction*		39A Al	39B Al
Manufacturer Concentration	ppm	10.2	107
RTI Concentration	Date	8/18/82	8/18/82
	ppm	(10.6)	(90.4)
	Day	28	28
	ppm	(11.0)	(103)
	Day	69	69
	ppm	(9.74)	(106)
	Day	728	728
	ppm	(6.90)**	(80.8)**
	Day	833	833
	ppm	(8.97)	(97.3)
	Day	1031	1031
	ppm	(9.11)	(98.4)
	Day	1346	1346
	ppm	(9.19)	(108)

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Questionable value.

ANALYTICAL CONDITIONS: Flame ionization detector, 20 ft. x 1/8" SS column packed with 10 % SP-1000 on 80/100 Supelcoport at 100 degrees Celsius.

CALIBRATION: A pressure-dilution technique is utilized for making a series of standards from reagent grade acrolein.

40.0 CHLOROBENZENE STABILITY STUDY

Cylinder No. Cylinder Construction*		40A S	40B Al	40C Al
Manufacturer Concentration	ppm	9.66	14.84	4.89
RTI Concentration	Date	8/6/82	10/11/83	10/11/83
	ppm	(9.03)	(14.7)	(4.19)
	Day	39	612	612
	ppm	(9.15)	(13.4)	(4.74)
	Day	75	1059	1059
	ppm	(9.20)	(14.4)	(5.01)
	Day	380		
	ppm	(9.62)		
	Day	1043		
	ppm	(8.11)**		
	Day	1490		
		(9.22)		

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Questionable value.

ANALYTICAL CONDITIONS: Flame ionization detection, 20' X 1/8" stainless steel column packed with 10% SP-1000 on 80/100 mesh Supelcoport at 150 degrees Celsius.

CALIBRATION: A pressure-dilution technique is utilized for making a series of standards from reagent grade chlorobenzene.

41.0 CARBON DISULFIDE STABILITY STUDY

Cylinder No.		41A	41B
Cylinder Construction*		Al	Al
Manufacturer		108	108
Concentration			
RTI Concentration	Date	7/14/82	2/21/85
	ppm	(100)	(101)
	Day	34	110
	ppm	(114)	(98.0)
	Day	72	477
	ppm	(116)	(104)
**			

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Cylinder empty.

ANALYTICAL CONDITIONS: Flame photometric detector, 4.6' X 1/4" Teflon® column packed with Carbopack B HT 100 at 75 degrees Celsius.

CALIBRATION: A pressure-dilution technique is used for making a series of standards from reagent grade carbon disulfide.

ANALYTICAL PROBLEMS: There is significant peak "tailing" unless a very high flow rate is used. "Tailing" is also caused by "bleed" from the sample loop. Sample valve should be in the inject position for exactly 5 seconds and then switched back to the sampling position to attenuate tailing. All sample lines and regulators must be conditioned extensively.

42.0 EPA METHOD 25 GAS MIXTURE STABILITY STUDY*

Cylinder No.		42A	42B	42C	42D	42E	42F
Cylinder Construction***		Al	Al	Al	Al	Al	Al
Manufacturer	ppmC	100	100	200	750	1000	2000
Concentration							
	Date	3/16/83	3/16/83	3/16/83	3/16/83	3/16/83	3/16/83
	ppmC	(102)	(107)	(205)	(775)	(1040)	(1940)
	Day	483	483	**	483	483	483
RTI	ppmC	(97.9)	(104)		(779)	(1060)	(1930)
Concentration	Day	**	**		726	726	726
	ppmC				(765)	(1020)	(1930)
	Day				1079	1079	**
	ppmC				(806)	(1093)	

*:

Gas Mixture contains an aliphatic hydrocarbon, an aromatic hydrocarbon, and carbon dioxide in nitrogen.

***:

Cylinder empty.

***:

Al = Aluminum; S = Steel; LS = Low Pressure Steel.

ANALYTICAL CONDITIONS: Flame ionization detector, Durapak n-octane on Poracil C column at 30°C for aliphatic hydrocarbon and 10% OV-101 on Chromosorb WHP column at 60°C for aromatic hydrocarbon.

CALIBRATION: An NBS-SRM is used as a standard for the aliphatic hydrocarbon. A pressure-dilution technique is utilized for generation of a series of standards from reagent grade liquid for the aromatic hydrocarbon.

42.0 EPA METHOD 25 GAS MIXTURE STABILITY STUDY* (Continued)

Cylinder No. Cylinder Construction**		42G Al	42H Al	42I Al	42J Al	42K Al	42L Al
Manufacturer Concentration	ppmC	96.7	98.6	147.6	151	198	197.5
RTI Concentration	Date	12/11/84	12/11/84	12/11/84	12/11/84	12/11/84	12/11/84
	ppmC	(96.4)	(98.9)	(149)	(153)	(195)	(195)
	Day	90	90	90	90	192	90
	ppmC	(95.8)	(93.3)	(144)	(145)	(183)***	(187)
	Day	443	443	443	443	443	443
	ppmC	(99.2)	(99.6)	(146)	(149)	(196)	(196)

*Gas Mixture contains an aliphatic hydrocarbon, an aromatic hydrocarbon, and carbon dioxide in nitrogen.

**Al = Aluminum; S = Steel; LS = Low Pressure Steel.

***Questionable value.

43.0 1,2-DIBROMOETHANE (ETHYLENE DIBROMIDE) STABILITY STUDY

Cylinder No. Cylinder Construction*		43A S	43B S	43C S	43D S
Manufacturer Concentration	ppm	10	20	100	300
RTI Concentration	Date	10/24/84	10/24/84	10/24/84	10/24/84
	ppm	(9.3)	(17.5)	(96.1)	(266)
	Day	54	54	55	55
	ppm	(9.3)	(17.5)	(107)	(344)**
	Day	243	243	243	516
	ppm	(8.66)	(15.4)	(84.0)	(250)
	Day	516	518	518	
	ppm	(9.27)	(15.9)	(75.1)	

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

**Questionable value.

ANALYTICAL CONDITIONS: Flame ionization detector, 5% OV-101 on Chromosorb WHP column at 60 degrees Celsius.

CALIBRATION: A pressure-dilution technique is utilized for making a series of standards from reagent grade ethylene dibromide.

44.0 1,1,2,2-TETRACHLOROETHANE STABILITY STUDY

Cylinder No.	44A
Cylinder Construction*	S
Manufacturer Concentration	ppm 12.2
RTI Concentration	Date 10/9/84 ppm (11.6)
	Day 533 ppm (10.9)

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

ANALYTICAL CONDITIONS: Flame ionization detector, 5% OV-101 on Chromosorb WHP column at 100 degrees Celsius.

CALIBRATION: A pressure-dilution technique is utilized for making a series of standards from reagent grade 1,1,2,2-tetrachloroethane.

44.0 1,1,2,2-TETRACHLOROETHANE STABILITY STUDY

Cylinder No.	44A
Cylinder Construction*	S
Manufacturer Concentration	ppm 12.2
RTI Concentration	Date 10/9/84 ppm (11.6)
	Day 533 ppm (10.9)

*Al = Aluminum; S = Steel; LS = Low Pressure Steel.

ANALYTICAL CONDITIONS: Flame ionization detector, 5% OV-101 on Chromosorb WHP column at 100 degrees Celsius.

CALIBRATION: A pressure-dilution technique is utilized for making a series of standards from reagent grade 1,1,2,2-tetrachloroethane.